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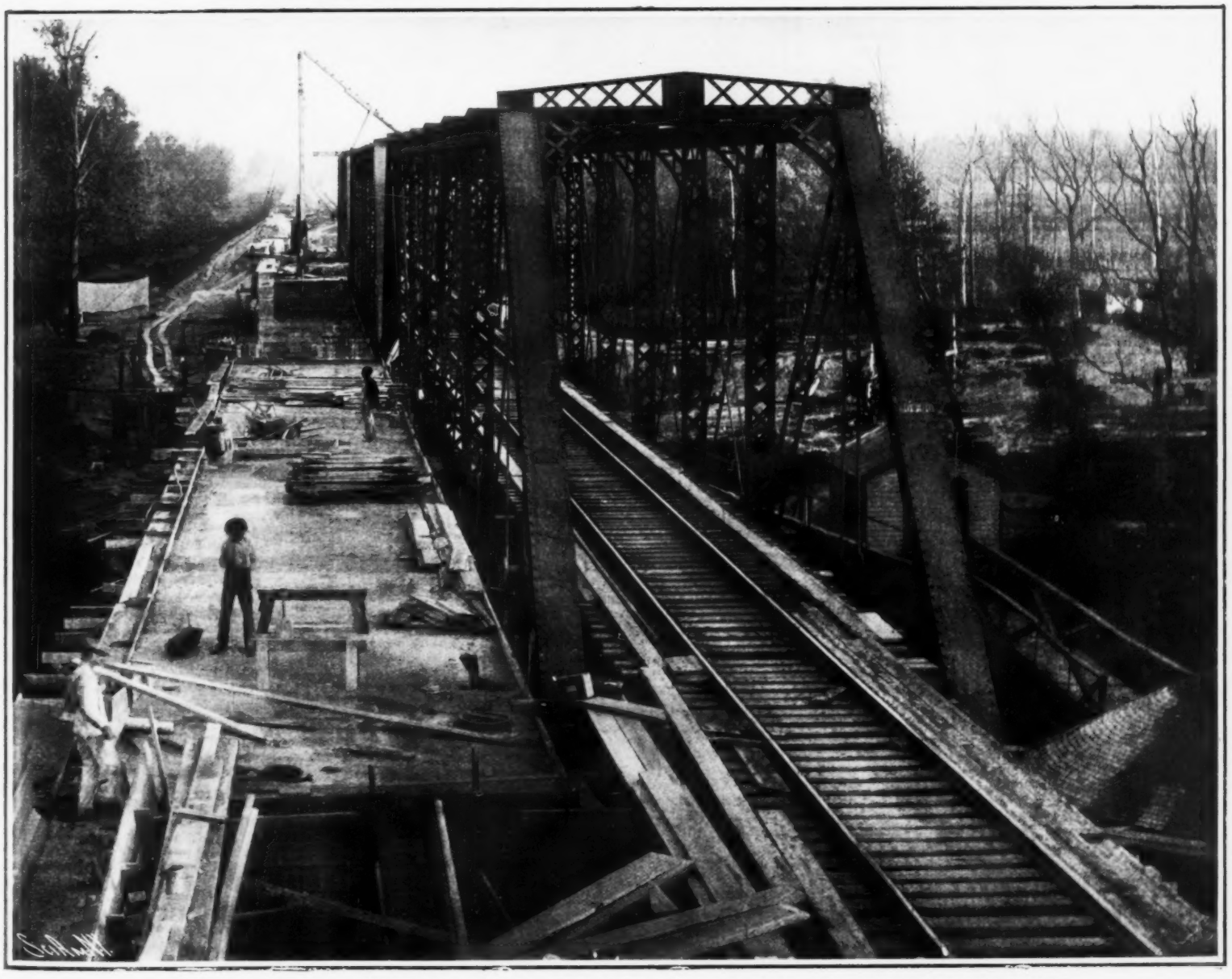
CONCRETE BRIDGE OVER THE BIG MUDDY RIVER, ILLINOIS CENTRAL RAILROAD.*

In double-tracking a part of the Illinois Central Railway, it was found necessary to replace the existing bridge across the Big Muddy River at Carbondale, Ill., about 300 miles from Chicago, by a more substantial one. The former, a three-span, single-track, Pratt truss bridge, was built in 1889, and by 1901 the traffic had grown to such proportions that the structure was found to be too light. The new bridge also consists of three spans, each an elliptical arch, and is built almost entirely of concrete. During the entire period of construction, about twenty months, traffic was uninterrupted. Work was begun in the autumn of 1901, and by May 10, 1903, the bridge was in regular use.

The arches are each of 140 feet clear span, while from center to center of the piers is 161 feet. The piers of the old bridge were 9 to 10 feet thick at the base. The thickness at the springing lines was increased to 21.5 feet in the new structure. This permitted the old masonry, which was used in the new piers, to be covered by 6 to 7 feet of concrete. The height, from low-water level to the original base of rail—the tracks were raised 5 feet—is 45 feet, the rise of the arch being 30 feet. The arches are el-

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE CARBONDALE BRIDGE. LENGTH, 574 FEET 5 INCHES; ARCHES, 140 FEET EACH.



THE CARBONDALE CONCRETE BRIDGE IN COURSE OF CONSTRUCTION. OLD BRIDGE TO THE RIGHT.

lipses whose major and minor axes are respectively 140 and 60 feet. At the crown, the thickness of the arch is 5 feet. Theoretically, this thickness should have been 5.33 feet, but because of the heavy reinforcement by the spandrel work and the copings, the first figure is more than sufficient to give the required strength. The minimum actual thickness of concrete at the crown of the arch is 7 feet.

The spandrel arches are built up around a steel skeleton. This is a complete self-supporting, internally braced and bolted structure. The vertical supporting posts rest upon and are bolted to transverse horizontal rails, which are set in recesses in the upper concrete surfaces of the arches. These posts are spaced three feet apart transversely and at longitudinal distances corresponding to the span of the spandrel arches. They are connected by rods 1 inch in diameter. The upper part of the skeleton consists of eleven longitudinal lines of horizontal rails, 3 feet apart center to center. These rails are tied and braced by 1-inch rods 18 inches apart, similar to those binding the vertical posts. Each rod is tightly bolted to the web of the rail by two nuts. The rails are joined end to end by ordinary splice bars. The vertical posts are joined to transverse horizontal rails by adjustable diagonals, which lie completely within the haunches of the arches. It was found that this kind of structure gave very little trouble in erection. It was erected, adjusted, and firmly bolted by ordinary labor, the absence of all rivets being an especial advantage. As a level floor was easily laid on top of the structure, and as the mold forms could be wired to the framework, the concrete was worked in with ease and rapidity. The cost of the skeleton was slightly less than one-quarter of a cent per pound.

From borings made at each pier, to determine the nature of the underlying material, it was found that the rock was at too great a depth to use in the foundations. Strata of clays and shale suitable for piling were found above the rock. Additional piles were driven around the old piers, as it had been decided to use these in the new bridge, their condition being generally good. In order to increase the strength of the new piers, the added masonry was carried to a depth from 4 to 13 feet lower than that of the existing stone work. The piles, generally of oak and from 30 to 35 feet long, were driven around the piers by a creeping driver, and around the abutments by a derrick and a creeping driver. For the piles for the falsework and in other cases where the work was cramped and difficult of access, a derrick driver carrying a set of leads swung from a boom was used successfully. Considerable trouble was experienced, because stonework from some older bridge was found imbedded in the earth around the piers of the existing structure. These old foundation stones had to be removed before or coincident with the pile driving, and for this purpose coffer dams were constructed. As the river is narrow and not very deep, and it usually flows between the two piers, there was little difficulty in building the coffer dams and no serious trouble from leakage. While building the north abutment, it was found that a settling in the old masonry was due to the fact that several piles had been cut off too high, and in consequence had decayed. These piles were thereupon removed and replaced by concrete bonded by scrap rail. A similar treatment was accorded the south abutment, although there was no apparent settling, and in both cases the new masonry was carried far below the level of the old.

Originally it had been designed to have an earth and ballast filling between spandrel walls, but as subsequent temperature strains were liable to injure these walls, and in order to decrease the weight on the abutments, the plan was modified by the substitution of the transverse spandrel arches. The upper concrete surface of these is finished level about 2 feet below the base of the rails. This surface is covered by stone ballast, and the rails are laid on ordinary hewed ties imbedded therein. In the structure as built, the dead load on each pier is 7,660 tons, while under the first plan the weight would have been 8,850 tons, a saving of nearly 1,200 tons.

To avoid danger from cracks due to temperature changes, the main ribs were built as a series of voussoirs. The real joints are about 8 feet apart. Intermediate false joints similar in style were made on the exterior faces of each voussoir. All the radial joints extend across the molding with which the top of the main arched rib is finished, and corresponding joints extend across the soffit from face to face of the arch. Additional provision for expansion due to a rise of temperature was made in the construction of the spandrel arches, by connecting the longitudinal rails by splices having some play, but especially by the sliding arches and expansion joints at each pier and abutment. At each pier there are two expansion joints, and one at each abutment, making six in all.

As no interruption of the traffic was permissible, the cost of the framework was heavy. In order to decrease the grade at the point where the bridge was constructed, it was decided to raise the tracks five feet, the new bridge to be correspondingly higher. The old structure was raised the necessary five feet by means of jacks, and subsequently supported on cribbings of timbers on the piers. This procedure permitted the construction of the main rib of the arch under the old bridge. The centering of the north and south arches was set up a little over one inch above the calculated elevation of the finished concrete, to allow for the compression and settling of the false work. In the case of the north arch, this extra elevation was found to be insufficient, though the difference in the final height may have been due to temperature changes. The middle arch was purposely centered a trifle higher than the remaining two.

No so-called natural hydraulic cement was used, the entire structure being built of Portland cement concrete. One factor that contributed to the decision to use only Portland cement was the fact that the contract was not closed till late in the fall, and the use of this material was necessary to insure the progress of the construction during the coldest weather. Moreover, the nature of the structure was such that only the best available material could be used, but great care was taken to vary the character of the mixtures, in order to keep the cost as low as possible, by modifying the proportions of cement, sand, and crushed stone in accordance with the service to which the structure might be subjected. The cement used was manufactured by the German-American Portland Cement Works, of La Salle, Ill., and is known as the "Owl" brand. Each and every carload was tested before use, and of 15,000 barrels employed in the construction, not one was rejected. Nearly all the mixing was done by machines, which could be set up or taken down, and moved from place to place with little difficulty, so that the concrete did not have to be transported far to reach the point where it was to be applied.

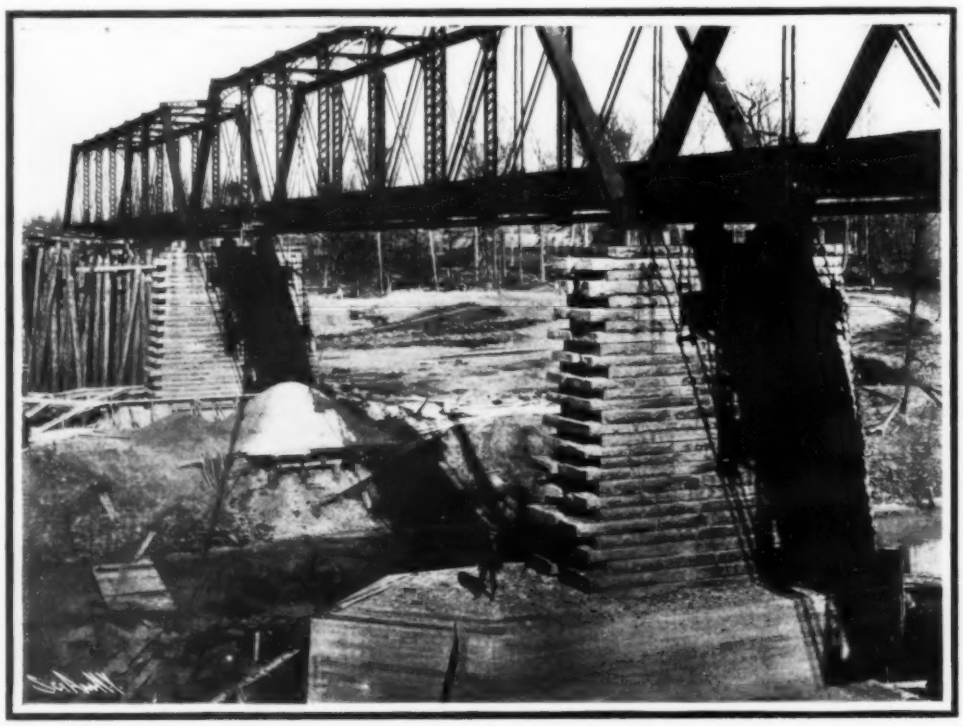
In the foundation work, the crushed stone and sand were usually delivered through the flooring of the old bridge to convenient points near each pier or abutment. Here the concrete was mixed by hand or machinery. The mixed material was delivered from runplanks by wheelbarrows, and shoveled and tamped in place. In the case of the voussoirs of the main arches, the concrete was delivered from the mixers by derricks. The derricks handled tubs of about a cubic yard capacity. In some instances the buckets were dumped on planking, the mixed concrete reloaded into wheelbarrows, and then delivered where required. As mentioned above, one-half of each main arch was constructed beneath the old bridge, the work progressing while the regular traffic was carried on across the structure. This caused some trouble, necessitating extra handling of concrete, delivering, placing and ramming in cramped and awkward positions.

The concrete work on the western half of the spandrel arches was also handled by derricks, but on the eastern half a concrete mixer mounted on a flat car was used, the old spans having previously been removed and temporary tracks run out on the skeleton steel frame.

All the exposed work was faced with mortar, and while this was generally too fluid to give the desired thickness of 1½ inches, the finish was uniformly excellent, as even a small amount of the mortar gave excellent results. All the exposed horizontal surfaces such as the copings, received a hard trowel finish. No attempt was made to remove the marks of the planks of the forms, and only a very small amount of pointing was done on exterior surfaces, for as a rule the employment of facing mortar made this unnecessary.

Two distinct forces of men were at work on the bridge—those employed by the contractor for the concrete work and the men in the service of the railroad. From various causes, the latter were seriously hindered by delays and stoppages, and were unable to work upon the structure for longer or shorter periods. Notwithstanding, the entire cost of the bridge was only $125,000, all things considered, a low amount for a structure of this character.

Mr. H. W. Parkhurst, engineer of bridges and buildings of the Illinois Central Railroad, had general charge of the work. The contractor for the concrete work was G. H. Scribner, Jr., of Chicago.



HOW THE MASONRY OF THE OLD BRIDGE WAS USED IN BUILDING THE NEW PIERS.

GOLD AND ITS ASSOCIATIONS.*

By GEORGE P. MERRILL, Curator of National Museum

IN connection with one of the recent expositions, I prepared a series of specimens illustrating the associations and mode of occurrence of gold and silver in nature. At the close of the exposition the collections were returned to Washington and installed with other collections of their kind in the National Museum.

Some recent discussions in the industrial journals relative to the associations of gold, have made it appear that the publication of the list of associations in the collection at the present time might not be without interest. It should be noted that in all the cases here enumerated the gold occurs free, or native, and in particles of sufficient size to be recognizable by the unaided eye.

Ores yielding gold on treatment, but in which the form of occurrence is in the least open to doubt, are not given. The specimens, it should be stated, are on exhibition in the National Museum, mainly in the Division of Practical Geology, although a few are in the mineral collection. The numbers refer to the Museum catalogue:

1. Native gold with pyrite residue (limonite) and evidently set free through oxidation. Many localities.

2. In compact clean white quartz, without trace of pyrite or its decomposed products. Many localities.

3. With telluride residue, and evidently set free by decomposition of tellurium compounds. Telluride, Colorado.

4. With platinum. Black sand from Condoto River, Colombia, S. A. (73,065.)

5. Native gold with iridosmine. Cross County, Ore. (64,749.)

6. Palladium gold. Near Sutara, Brazil. (14,235.)

7. Electrum. Hungary. (44,384.) California. (49,159.)

8. Native gold with hessite and chalcopyrite. Milky quartz abundantly injected with pyrrhotite and hessite; the gold occurring with the latter. Melones mine, Calaveras County, Cal. (44,051.)

9. With altaite in calcareous rock. The gold plainly visible in small flecks, at times intimately associated with the altaite or again quite free from it. Rock gray-white, with the general appearance of a crystalline limestone. In thin sections. An aggregate of muddy calcites and an occasional quartz granule. King's Mountain, N. C. (63,363.)

10. With altaite and pyrite in quartzite. A vein-quartz thickly injected with the minerals noted. Gold not abundant, occurring in small flecks easily recognized by the pocket lens and evidently more closely associated with the altaite than the pyrite. Providence mine, Nevada County, Cal. (62,779.)

11. With alloclasite in calcite. A cleavage mass of calcite with radiating clusters of alloclasite and small specks of gold. The latter occurs both in the mass of the alloclasite and free from it. Oravicza, Hungary. (62,855.)

12. With stibnite in quartz. A milky quartz with gold, sometimes with the stibnite, but mostly quite free from it. Rock slickensided, with gold showing plainly on slickensided surface, indicating that movement took place after its deposition. New Zealand. (5,710.)

13. With stibnite on quartz. Drusy quartz with stibnite and gold, the two sometimes together, sometimes separate. Kremnitz, Hungary. (62,810.)

14. With stibnite in quartz. A blue-gray vein-quartz strongly impregnated with stibnite and with areas

* Reprinted from Engineering and Mining Journal.

likewise impregnated with gold. No evident connection between the two, the minerals being sometimes associated and sometimes distinct. Hopeful mine, Reefton, New Zealand. (11,760.)

15. With bismuthinite, bismuth and galena, in quartz. A coarsely crystalline milky vein-quartz, with bismuthinite and some bismite and abundant galena. Gold mostly with bismuth compounds. Katharinenburg, Russia. (40,304.)

16. With pyrite, arsenopyrite and galena, in quartz. Milky quartz, with pyrite, arsenopyrite and galena. Gold occurs for the most part in the arsenopyrite. (83,811.)

17. With dolomite, arsenopyrite and quartz. Lake mountain, Alaska. (5,656.)

18. With pyrite in calcareous quartzite. A dark-gray quartzite containing some calcite and disseminated pyrite, with free gold. No evident connection between the gold and pyrite. Eldorado County, Cal. (81,786.)

19. With pyrite and quartz in slate. A blue-gray siliceous slaty rock, with pyrite and some gold. Gustin mine, Lawrence County, S. D. (20,153.)

20. In pyrrhotite. Massive pyrrhotite, fresh and oxidized, with large enclosures of gold. Some chalcopyrite and quartz. Cable mine, Cable, Mont. (75,528.)

21. In milky quartz, with calcite, pyrrhotite and polybasite. A small mass of milky quartz enclosed in white, coarsely crystalline calcite, and enclosing polybasite and gold in juxtaposition. Small specks of pyrrhotite. Cable mine, Deer Lodge County, Mont. (75,548.)

22. In gangue of sphalerite, galena, pyrite and quartz. White quartz abundantly impregnated with galena, sphalerite and pyrite, and carrying gold. Locality unknown. (62,910.)

23. With tetrahedrite in quartz. Milky quartz, with disseminated tetrahedrite and small flecks of gold. Baker City, Ore. (17,062.)

MAIN ARCHES IN COURSE OF CONSTRUCTION.

24. With argentite, in quartz. Takatama, Japan. (61,431.)

25. With galena, in quartz. Milky quartz with galena. Gold closely associated with galena. Montgomery County, Md. (49,527.)

26. With galena, in quartz. Milky quartz, with galena encrusted with gold, and also gold with no galena. Englehawk, Bendigo district, Victoria. (30,670.)

27. In silicious breccia. A brecciated silicious rock in which the gold seems to serve as a cement. Johannesburg, South Africa. (53,680.)

28. In gangue of quartz, calcite and epidote. Milky quartz so abundantly injected with small epidote as to give the whole mass a greenish color. Some minute pyrite and an occasional small particle of gold in the quartz and seemingly bearing no relation to the pyrite. Siam. (34,420.)

29. On slickensided surface of smoky quartz. A mass of coarsely granular crystalline smoky quartz, with one surface blackened and slickensided, showing abundant thinly drawn-out plates of gold. Coraes, Minas Geraes, Brazil. (30,722.)

30. In opalescent quartz. A brownish impure opal, evidently of same nature as the next. (29,694.) Red Bluff lode, near Virginia City, Mont. (29,698.)

31. In chalcedonic quartz and opal. A small mass of whitish chalcedony, with cavities filled with milky opal. Gold rare and in small flecks. The rock is evidently a hot-spring deposit, but may be a quartzite altered by hot-spring action. Nevada City, Nev. (29,694.)

32. In jasper. A coarse conglomerate composed of pebbles of brown jasper cemented by crystalline quartz. Gold in the jasper pebbles. Lone Star mine, Nevada County, Cal. (14,935.)

33. In magnetite. A bit of lamellar magnetic iron, with thin flecks of gold between the laminæ. Mineral Hill mine, Carroll County, Md. (68,028.)

34. On hematite. A small mass of deep blue-black specular hematite, thickly coated on one surface with gold. Brazil. (53,746.)

35. In calcite. A coarsely crystalline gray-brown calcite, with abundant sprinkling of gold, which is distributed without reference to cleavage lines. Particles small. Gympie, Queensland. (83,831.)

36. In calcite. Described briefly by J. S. Diller, American Journal of Science, Vol. 39, 1890, p. 160. Minersville, Cal. (48,919.)

37. In fluorite, with calcite. A gray crystalline granular limestone, with segregations of fluorite. Gold in the fluorite; rusty and doubtless set free by decomposition of tellurides. Judith Mts., Mont. (53,081.)

38. With cerargyrite. A silicious, highly altered rock, with scales of horn-silver and minute flecks of gold. Mahogany mine, Owyhee County, Idaho. (14,775.)

39. In mica schist. A deep blue-black fine-grained schist, containing gold leaflets lying along plane of foliation. No visible sulphide. Chile. (11,981.)

40. In chlorite schist. A deep green chlorite schist, with occasional pyrite and flecks of gold drawn out in direction parallel with schistosity. Black Hills, S. D. (75,571.)

41. With pyrite in mica schist. A dense, coal-black schistose rock, with an ill-defined vein of pyrite cutting obliquely across the schistosity, and carrying a little gold intimately associated with the pyrite. Cabarrus County, N. C. (62,911.)

42. In hornblende schist. A black, hornblendic schistose rock (diorite), with a little gold. Cross mine, Pennington County, S. D. (67,915.)

43. In selenite. Wire and dendritic gold in selenite. Old Abe mine, White Oaks, Lincoln County, N. M. (84,474.)

44. In barite. A weathered and cavernous mass of barite on surface of silicious rock, and containing abundant flecks of sponge gold. No sulphides. Mexico. (62,230.)

45. With roscoelite, in quartz. A granular quartzite, with scattering segregations of roscoelite, the latter sometimes carrying a little gold. Stockslager mine, Eldorado County, Cal. (84,452.)

46. In halloysite. Cerro Colorado, Batopilas, Mex. (63,719.)

47. In granite. A mica granite of medium texture, with leaf and dendritic gold, sometimes microscopic in the feldspar and quartz. Described by Geo. P. Merrill in American Journal of Science, April, 1896. Pozo Prieto mine, Altar district, Sonora, Mex. (64,987.)

48. With albite, in porphyry. A white crystalline granular albite segregation in a dark porphyry, much fine pyrite along line of contact. Gold interstitial in albite, and seemingly independent of pyrite. Show mine, Eldorado County, Cal. (63,371.)

RELATIVE INDUSTRIAL VALUE OF THE THUMB AND FINGERS.

THE THUMB.—The different fingers are far from having the same value with reference to their functional utilization. Much the most important is the thumb, for without it prehension would be very imperfect. The hand is no longer pincers, but merely a claw, when deprived of the thumb. It may be estimated that the thumb represents fully a third of the total value of the hand. The total loss of the thumb is estimated by Brouardel, secretary of the Société de Médecine Légale, as 15 to 35 per cent for the right, and 10 to 15 per cent for the left hand, except for workers in art, when he estimates 40 to 50 for the right, and 25 to 40 per cent for the left hand. The Austrian schedule gives 15 to 25 per cent. In Germany, 20, 28, and up to 33.3 per cent has been awarded. On account of the great difference resulting in our opinion from the use of both hands, we prefer, in the professions not requiring special hand skill, 30 per cent for the right and 20 per cent for the left. The percentage is based on 100 as the total industrial value of the hand previously to the accident, a loss of 50 per cent representing half of that value, and a loss of 25 per cent one-fourth, etc.

The Index Finger.—The total loss of the index finger causes an incapacity estimated at 10 to 15 per cent in Austria; 16 to 20 per cent in Germany; 15 to 25 per cent by Thiersch; 20 per cent for the right and 15 per cent for the left by the Italian courts; 15 per cent by the French tribunals; 10 to 15 per cent for the right and 5 to 15 per cent for the left by Brouardel, except for workers in art. These figures differ but little from one another, and the figures from 10 to 20 per cent according to the side, may be adopted.

The Middle Finger.—The total loss of the middle finger is regarded by Golebiewski as often more prejudicial than that of the index; this is an isolated opinion; almost all the authorities ascribe less importance to the middle finger than to the index. Yet a great loss of force is observed in the hand when the finger is amputated. The following are estimates: The Austrian tariff, 5 to 10 per cent; Brouardel, 5 to 15 per cent, except for workers in art; Thiersch, 10 to 20 per cent; the Italian law, 5 per cent. The figures 8 to 12 per cent often are nearest the truth.

The annular (ring) finger is the least important. Its total loss often does not cause incapacity. The Austrian tariff assimilates this finger to the middle one. Brouardel estimates the loss at 5 to 10 per cent; the Italian law, 8 per cent. The French and German judicial decisions are often in accord in refusing indemnity, considering the incapacity resulting from the loss as very slight.

The auricular (little) finger may be compared to the annular, except in the professions in which it serves as a point of support for the hand.—Condensed from Report of Drs. Ollive and Le Meignan of the Ecole de Médecine de Hautes, in Précis des Accidents du Travail.

CONTEMPORARY ELECTRICAL SCIENCE.*

SPONTANEOUS IONIZATION.—A. Wood confirms the probability that all matter is to some extent radio-active, and that the disintegration processes, going on in radium and the other radio-active elements, are going on also (though to a very much smaller extent) in all matter. He finds that the natural ionization of the gas in a vessel has at least a threefold origin, part of it being due to a penetrating radiation from without, part to a secondary radiation from the walls of the vessel excited by the former, and part to an intrinsic radiation from the walls, completely independent of the external radiation. This intrinsic radiation varies considerably from one metal to another, and does not seem to be due to impurities of the known radio-active elements since it does not vary much in different specimens of the same metal. The author used an apparatus consisting of a brass plate mounted on a quartz pillar and facing a gold leaf. The brass plate was charged, and the deflection of the gold leaf observed at definite intervals. The whole was inclosed in a tin box surrounded with asbestos. Boxes of various materials were placed round the whole apparatus, and these again were screened off with iron or lead screens. The author was unable to determine the direction in which the all-penetrating radiation from outside arrives, but that it did not account for the whole of the spontaneous ionization was shown by the manner in which the latter varied with the pressure of the gas.—A. Wood, Philosophical Magazine, April, 1905.

ORIGIN OF RADIUM.—The constant proportionality found in most minerals between the uranium and the radium in them lends color to the supposition that radium is a product of the disintegration of uranium. B. B. Boltwood has endeavored to throw further light on this important probability by carefully examining a large number of minerals of various origins, including pitchblende from Joachimsthal, Colorado, and North Carolina, uranothorite, euxenite, thorite, fergusonite, and monazite from Norway, monazite from Brazil and Connecticut, and allanite, gummite, uranophane, and samarskite from North Carolina. All the analyses point to uranium as the parent of radium. The participation of thorium in the production of radium, as suggested by some, is entirely excluded, since the radium-uranium ratio in the thorites, containing approximately 50 per cent of thorium, is the same as that in such minerals as carnotite and uranophane, where the proportion of thorium is not over a few hundredths of 1 per cent at the highest. All the monazites contain notable quantities of uranium and radium, and this affords a plausible explanation of the occurrence of helium in this mineral without recourse to the unsubstantiated hypothesis of the formation of helium from thorium. The age of monazine is extreme, since it occurs in some of the oldest igneous rocks of the globe. It may, therefore, be assumed that it originally contained much more uranium than at present, and that the accumulated helium represents the disintegration product of radium for countless ages.—B. B. Boltwood, Philosophical Magazine, April, 1905.

The farmer is a wealth-producer. Therefore, his importance in the body politic is primary. He deals with elemental forces. As a wealth-producer, he will come to have a larger voice in the expenditure and waste of wealth in maintaining armaments of war. All his instincts are of peace.

* Compiled by E. E. Fournier d'Albe in the Electrician.

THE LISTER TWO-CYCLE TWIN-PISTON ENGINE.

THIS engine, in common with all two-cycle engines, has an operative impulse at each revolution of the single crank shaft in contradistinction to the impulse every two revolutions in the Otto principle. The construction of the engine may be gathered from the sectional view of the engine in the adjoining diagrams. It consists of two parallel cylinders, *A* and *B*, the former being the exhaust and the latter the inlet cylinder, a compression chamber common to both being arranged between the two cylinders. The piston of each cylinder is connected by rods, R^1, R^2, to a triangular frame, *C*, one angle of which is coupled to the crank pin, and the movement of the frame, *C*, is controlled by the bridle or radius rod, *L*, pivoted to the casing of the engine.

We will now describe the motion of the pistons with reference to the diagrammatic representations. On the rotation of the crank in the direction of the arrow, commencing with the position at the completion of the compression stroke, as shown in the middle figure, the ignition takes place, and the pressure generated acts simultaneously on both pistons; the piston, *B*, immediately begins to travel in advance of the piston, *A*, and has approached the end of its outstroke by the time the piston, *A*, has arrived at the exhaust port. The volume is then as shown in the expansion figure; the exhaust now takes place and the pressure immediately drops to atmospheric. The piston, *B*, having uncovered an inlet port provided with a back-pressure valve connected by a passage to the inclosed crank chamber, allows a volume of air under pressure to pass from the crank chamber into the cylinder, *B*, in order to sweep out the whole of the products of combustion of the previous explosion from the cylinder and compression space. The piston, *B*, then commences its stroke again in advance of the piston, *A*, and forces out a further volume of contents from the cylinder, *A*, and approaches the end of its in-stoke at the point when the piston, *A*, is closing the exhaust port, the volume before compression being then as shown in the charge diagram. Shortly, however, before the closing of the exhaust port, a charge of gas, oil, or spirit vapor or liquid fuel is pumped into the cylinder, *B*, in such a manner as to mix intimately with the air therein, forming an explosive mixture, which is then compressed, ignited, and the cycle is repeated at each revolution.

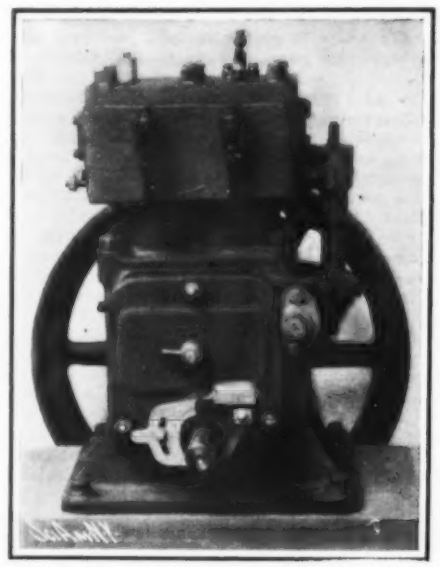
The main features of utility claimed in this engine may be summarized as follows: An increased expansion of the working fluid, i.e., the volume of cylinder contents at the point of exhaust, is from 50 to 70 per cent greater than the initial volume of charge before the commencement of compression, resulting in increased economy, better combustion, and consequent reduction in the smell of the exhaust, and a practically noiseless exhaust. A free exhaust port, thus avoiding loss from back pressure. A positive scavenging action without any loss of incoming explosive charge. A rapid expansion and consequent reduction in cylinder wall losses. Short connecting rods, with a greatly reduced angle of pressure, not exceeding 5 deg. at any point of the working stroke, with the advantage of equal cylinder and piston wear and good lubrication. A definite full charge of explosive mixture at all speeds and under all conditions of temperature.

The general effect of the above conditions is that an engine can be constructed having a small unit of weight per horse-power, which occupies a very small space, and has a high efficiency. The engine can be governed by an ordinary rotary engine governor, or by hand in marine work by varying the volume of the pump charge within the working limits of explosive mixture.

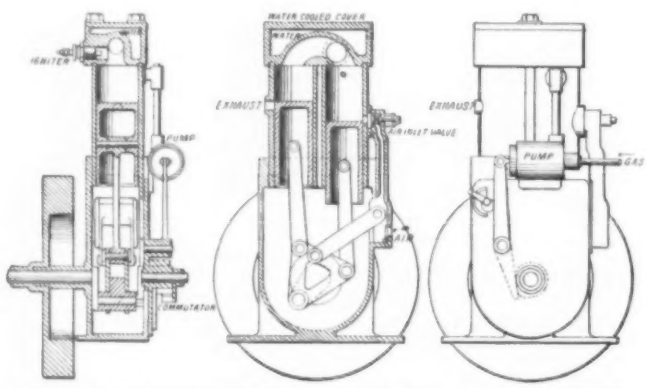
It is interesting to note from the diagram that the initial volume of charge is expanded to 1.7 before exhaust takes place, which is largely responsible for the advantages set out above. The combined effective power strokes of the two pistons are approximately equal to 1.8 of the crank stroke, the compression portion of the return stroke being equal to 1.2 of the crank stroke.

The engine can be run with petroleum, petrol, acetylene, or other explosive agent, any of which can be used on a launch; for tugs and other purposes where more than 8 horse-power is necessary, the inventor recommends the installation of a small anthracite coal-gas producing plant, which will occupy about the same space as the engine. It has been found, we understand, that an engine of 20 horse-power can be run at full power for 3d. to 4d. per hour, with no smell arising from the producer or the exhaust.

The inventor of this engine is Mr. F. Lister, engineer, of Keighley, England, a gentleman who has given much attention to this class of motor. The engine has been patented recently in this country.



THE LISTER TWIN-PISTON TWO-CYCLE GASOLINE MOTOR.



CROSS AND LONGITUDINAL SECTIONS AND SIDE VIEW OF LISTER TWIN-PISTON TWO-CYCLE MOTOR.

OIL MILLING IN THE DON DISTRICT.

IN the regions watered by the Don, there are about four hundred oil mills, which occupy themselves mostly with extracting oil from the *sturepa*, a plant which is destroyed as a weed in other localities. The fruit is also called *ravison*, and in German *Ruebsen*. The pressed cake is exported as a fertilizer. In the northern Caucasus, too, oil milling is an important industry, but the oil is made from the seed of the sunflower. The cultivation of the sunflower in these regions is intensely followed because there is money in it, at least for the time being, the price of one pound of seed being now about 70 kopeks. The sunflower exhausts the soil at a rapid rate, however, so that after two or three crops the soil is almost worthless for other cultivation, and if five crops of sunflowers are successively taken from it, not even grass will grow upon it afterward. The largest factories for this oil are at Jekaterinodar and Armawir, that consume about 4,500,000 *pud* of seed, turning it into oil valued at about 3,500,000 of rubles, and to oil cake to the value of about 1,500,000 rubles. In Armawir there are besides eight factories of this kind that have a yearly output of from 250,000 to 500,000 rubles of oil, and from 80,000 to 200,000 rubles of oil cake. To make the milling successful, an economical separation of the hulls is most important, for they are used as a fuel. The sifted kernels fall into the hoppers, and as they issue from between the stones they are put in hydraulic presses in layers, between which are other layers of camel's hair. The exuding oil is pumped into tanks, from which the casks are filled. On the spot the oil sold recently for 5 rubles 80 kopeks per *pud*. The market price varies between 4 and 8 rubles. The Jekaterinodar factory ships about five carloads (of 1,000 *puds* each) daily, while the output of Armawir is but two carloads, all of it going to the countryside immediately surrounding the scene of production. The pressed cake is used for cattle food, and is exported to Denmark, Norway, and Germany. The Russians themselves use the oil in the preparation of their Lenten fare.—Der Seifenfabrikant.

Cement for Metallic Letters.—The Praktischer Wegweiser recommends for this purpose a mixture of mastic 9, litharge 18, white lead 9, and linseed oil 27. These ingredients should be melted together, and the cement used hot.

Correspondence.

THE SVEA CALORIC ENGINE.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

Having been the consulting engineer to the Ericsson Coast Defense Company for a number of years, it has been my privilege to come in contact with many of Ericsson's old friends, and thereby gain a knowledge of the opposition which he experienced when he proposed to use air as the medium by which heat was to be converted into power.

Mr. Reeve's argument, recently published in a note to my article, that the expansive force of air cannot overcome friction in the cylinder and elsewhere, was then used with great force, and Ericsson had a perfect Niagara to contend with, until he got his engine running.

To try to disprove the same objection at this time, with more than 30,000 hot-air engines running in this country alone, would be out of place.

The fact that I am using air under a pressure of 10 kilogrammes per square centimeter for the 100-horse-power stationary engine, which I now have under way, thereby giving me the same pressure as in the gas engine, will also satisfy Mr. Reeve's second objection.

Let us consequently suppose that the hot-air engine is an actual fact, and that a 1-horse-power engine makes 75 revolutions per minute. Let us also suppose that a heater of reasonable size could be constructed, which would supply heated air fast enough to allow a double-acting engine to run 750 revolutions per minute. That would make the same engine 20 horse-power.

This is exactly what I accomplished in the Svea engine. My system of rapidly heating large volumes of air places me in a position to furnish all the necessary heated air for the largest power, without undue increase in weight and size.

My experience in designing both steam and gas engines will certainly assist me in properly working out all the details. They are not as formidable as those which confronted the gas engine pioneers.

Air is the poorest conductor of heat known, but the hot combustion gases will rapidly give off the heat of the surrounding water, when passing through the boiler tubes.

This process can be reversed with equally satisfactory results. Cold air passing through the same tubes with the same velocity will absorb the heat radiated from the heated tubes with the same rapidity.

It is this one great fact which I am impressing on those who supply the coal, and this I also wish to impress on those who control the water supply.

The two contending forces, fire and water, have hitherto carried the world forward, and it is my belief that they will continue to do so.

New York, May 1, 1905. G. EMIL HESSE.

JAPAN'S TRADE IN 1904.

THE annual return of the foreign trade of the empire of Japan in the year 1904, issued by the department of finance of that government and just received by the Department of Commerce and Labor through its Bureau of Statistics, presents the statistics of commerce of Japan during the past year, as well as data showing the proportion of its trade with each of the principal countries. Japan has made rapid progress in her foreign commerce during the past decade, and her trade with the United States shows an especially rapid growth.

The imports into Japan in 1904 were the largest on record, being $184,938,000 in value, as against $157,933,000 in 1903, $143,056,000 in 1900, and $66,311,000 in 1895. Exports from Japan in 1904 also established a new high record, being $158,992,000 in value, as against $144,172,000 last year, $101,806,000 in 1900, and $69,825,000 in 1895. Thus the imports into Japan have increased by $118,627,000 and the exports from Japan by $89,167,000 since 1895.

During the past ten years Japan has imported about $200,000,000 more than she has exported, the excess of the imports over the exports averaging about $20,000,000 annually during that period.

An examination of the statistics of commerce with the principal countries shows that Japan imports most largely from Great Britain, British India, the United States, China, and Germany, these five countries supplying about 77 per cent of her total imports. Of the total imports into Japan in 1904, amounting to $184,938,000, the United Kingdom supplied $37,346,000, or 20.2 per cent; British India (including Straits Settlements), $35,228,000, or 19 per cent; the United States, $28,942,000, or 15.7 per cent; China, $27,295,000, or 14.8

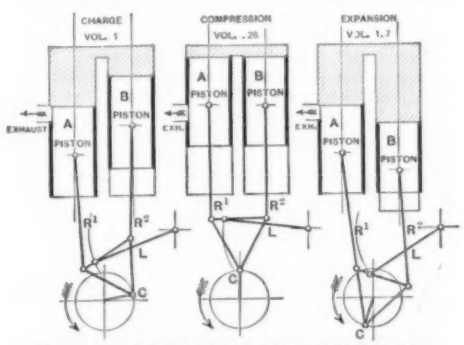


DIAGRAM SHOWING MOVEMENT OF PISTONS.

per cent, and Germany, $14,291,000, or 7.7 per cent.

Of the exports from Japan, amounting to $158,992,000 in 1904, the principal countries of destination are the United States, $50,423,000; China, $33,857,000; France, $18,087,000; Hongkong, $14,024,000; Korea, $10,154,000; Great Britain, $8,787,000, and Italy, $6,011,000, these seven countries taking about nine-tenths of the exports from Japan. It will be observed that the United States is by far Japan's best customer, exports to the United States from Japan representing about one-third of her total sales to foreign countries. Among the nations exporting goods to Japan, however, the United States occupies a lower rank, being exceeded in that respect by both Great Britain and British India.

In 1884 the United States supplied 8.4 per cent of Japan's imports, while the United Kingdom supplied 43 per cent; in 1889 the United States supplied 9.3 per cent, the United Kingdom 39.4 per cent; in 1894 the United States supplied 9.3 per cent, the United Kingdom 35.9 per cent; in 1899 the United States supplied 71.3 per cent, the United Kingdom 20.3 per cent, and in 1904 the United States supplied 15.7 per cent, and the United Kingdom 20.2 per cent. The United States has therefore increased its proportion from 8 per cent of Japan's total imports in 1884 to 16 per cent in 1904, while the United Kingdom, meantime, has lost ground relatively, having supplied 43 per cent of Japan's total imports in the former, and but 20 per cent of her total imports in the latter year.

The exports of Japan to the United States during the period in question increased at a rate far in excess of those to any of the leading European countries. As against a growth of total Japanese exports from $29,434,000 in 1884 to $56,017,000 in 1894, and to $158,992,000 in 1904, the exports to the United States for the same years show the following figures: 1884, $11,411,000; 1894, $21,488,000; and 1904, $50,423,000. In other words, while the total Japanese exports increased 90 per cent during the decade 1884-1894, and 184 per cent during the decade 1894-1904, the Japanese exports to the United States increased over 88 per cent during the decade 1884-1894, and about 135 per cent during the decade 1894-1904. During the latter decade the increase of the imports from the United States was 431 per cent, while the increase of the exports to the United States was 135 per cent.

The principal articles imported into Japan from the United States in the calendar year 1904, in the order of their magnitude, were: Kerosene oil, 5.5 million dollars; flour, 4.6 millions; raw cotton, 4.5 millions; machinery and parts thereof, about 2 millions; iron and steel manufactures, 1.9 millions; leather, 1.7 millions; cotton manufactures, 1.1 millions; wheat and other grains, canned provisions, cars and carriages, leaf tobacco, and coal, the last five items ranging downward and each showing figures less than 1 million dollars.

Japan's principal exports to the United States in the calendar year 1904 were: Raw silk and waste, 30.4 million dollars; silk manufactures, 6.1 millions; tea, 5.6 millions; mats and matting, 2.3 millions; porcelain and earthen ware, about 1 million dollars; and camphor, straw braids, wood-chip braids, sulphur, tooth brushes, and rice, ranging downward from $620,000 to about $300,000 each.

RECENT DEVELOPMENTS IN WIRELESS TELEGRAPHY.

An electric induction coil giving a high-frequency alternating current is used to charge a capacity which produces a vibratory discharge at the spark-gap. The length of the resulting waves ($\lambda = 2\pi\sqrt{LC}$) is determined by the size of capacity and the existing self-induction in the oscillatory system.

Let C (Fig. 1) represent the capacity (Leyden jar) and L the winding of an induction coil of an oscillatory circuit. We convey to it a definite amount of energy by a single charge of the induction coil, which energy, according to the law of the conservation of energy, is indestructible. If this quantity is great enough to produce a sufficient tension in the condenser layers, the electricity will overcome the considerable resistance of the spark-gap and oscillate back and forth in the circuit. The resistance of the circuit itself is very small; it absorbs only a very slight amount of energy in the form of heat; but the diminution of heat and light in the spark-gap is somewhat greater. The

FIG. 1.

longer the spark, the greater the loss; and in order to obviate this the gap is frequently placed in oil, because oil offers far greater resistance than air, and the balls can be brought more closely together. Other losses of energy are not likely to occur in our closed vibratory circuit; the separate oscillations lose only the amount of energy consumed in the spark-gap and in the circuit. The weakening of these outer almost unavailable oscillations is slight.

Fig. 2 represents a few diminished oscillations in the circuit. An analogue is found in acoustics in a tuning fork, which vibrates freely in the air, the vibrations of which continue a long time, but are so weak that they produce scarcely any sound. In order to render them audible the tuning fork must be placed on a sounding board, a table, etc., whereupon a distinct tone is given forth, even though for a short period only. We need only, therefore, connect our oscillatory circuit with a pair of wires, A and A' (Fig. 3), in order to obtain a quick, powerful effect. The oscillations of the circuit excite in the wires stationary waves and

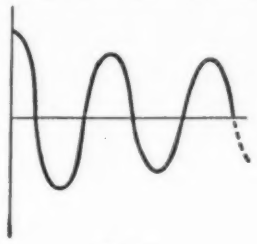


FIG. 2.

these send forth powerful impulses. But now, in addition to the loss of energy, not counting that of the spark-gap and the circuit, we have a loss through radiation of the transmitter. The oscillations would be greatly weakened, as seen in Fig. 4.

That an outward action is imperative in wireless telegraphy is self-evident. In direct coupling, or the connection of the transmitter with the oscillatory circuit,

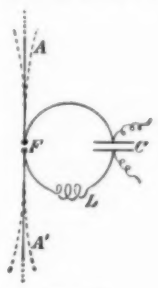


FIG. 3.

the outward action is momentarily greatest. This must be resorted to, therefore, in transmitting signals to a great distance.

If it is a question, however, of keeping the dispatch secret, and merely signaling the station the receiver of which is tuned to the same pitch as the transmitter, it is necessary to produce waves that are not so weak in order to obtain the desired resonance which is the

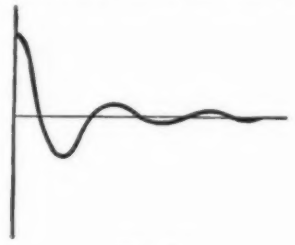


FIG. 4.

result of separate weak impulses combined to a relatively stronger action. The transmitter must not be coupled directly to the vibratory circuit, but loosely, so that energy may be conducted to it gradually as from a stored supply. This can be attained as gradually as required by "inductive coupling," by converting a few windings of the circuit into the primary coil of a small transformer (Fig. 5). The relation of the

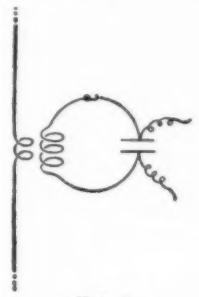


FIG. 5.

weakening of the oscillations in the vibratory circuit and of the waves sent out by the wires depends materially on the degree of coupling.

We have so far only considered the case of a single charging of the capacity, and the consequent oscillatory discharge through the spark-gap. The recharging of the capacity occurs at the next amplitude of the alternating current generated by the induction coil.

FIG. 6.

As, however, the frequency of the alternating current produced by the induction coil is very low in proportion to the extraordinarily rapid oscillations of the discharge, so the rapid oscillations cease long before the usual recharge takes place (Fig. 6).

Prof. Simon, the investigator well known through the "speaking arc," and M. Reich have been endeavoring for some time to convert a direct current into an uninterrupted series of high-tension alternating-current waves by following the analogy of the reed organ, in which a steady current of air is converted into a series of air waves. This alternating current would make a very high frequency possible and by means of it we

Cooper Hewitt Spark Gap

FIG. 7.

would be enabled to send far greater amounts of energy into space.

The spark-gap is then placed in a vacuum. A Hewitt mercury vapor lamp (Fig. 7) can be used for this purpose and in doing so there is a double advantage. In the first place, higher potentials can be utilized, and secondly, a spark-gap in a vacuum loses its conductivity much more rapidly than an air-gap, so that the "inactive spark"—during which the spark-gap has not time to lose its conductivity before a new impulse

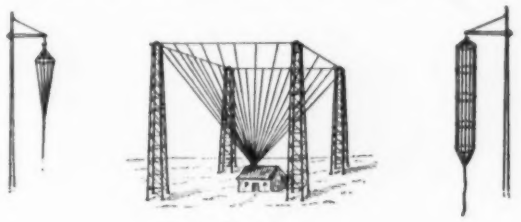


FIG. 8.

occurs—will be entirely overcome. Many experimenters have tried in vain to remedy this defect.

On one point, however, we would refer to the transmitting station. The first antenna, as shown in Prometheus, consisted almost solely of a thin wire, the alternating frequency of which was syntonous with the exciting oscillatory circuit. We have already seen that the length of the waves and indirectly the alternating frequency, is determined by the formula $\lambda = 2\pi\sqrt{LC}$. The greater the capacity of a conductor, so much greater is the energy it can appropriate and so much more powerful are the waves that it sends out. If we desire to increase the capacity, C, in our formula, without making λ any larger, we must reduce L, the

Castelli's Coherer

FIG. 9.

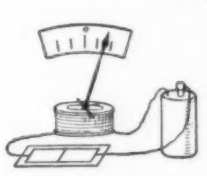


FIG. 10.

FIG. 11.

self-induction. This can easily be done in practice by replacing the single wire by a large number of conductors connected in parallel, of the same length and the same distance apart. By this means the capacity is increased without changing the frequency of the oscillations, as the amount of the self-induction lessens correspondingly.

The new antennæ (Fig. 8) thus frequently consist of a great number of wires, also of concentric metal cylinders, etc., which all serve the same purpose.

We will now consider the receiving-station. Here the number of coherers has increased considerably.

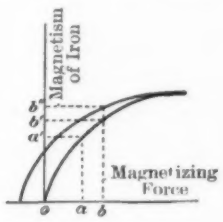


FIG. 12.

We will take into consideration only the principal kinds with their most important examples.

The principal groups are:

1. Wave detectors with loose contact and variable resistance: (a) conductivity increased by excitation (coherer); (b) conductivity lessened on excitation (anti-coherer).

2. Coherers (wave detectors) which make known the heat generated by the exciting energy.

3. Wave detectors which depend upon the magnetic action of the waves.

4. Electrolytic detectors.

The first group is not unfamiliar to us; the Branly

coherer, used by Marconi, is a typical example. It has undergone many modifications at the hands of its different investigators. The selection and combining of the filings, their degree of oxidation, magnetic influences, their manner of de-cohering or even purely external variations have occasioned an enormous number of new inventions, not all of which are of practical utility. More important for us are the de-cohering co-

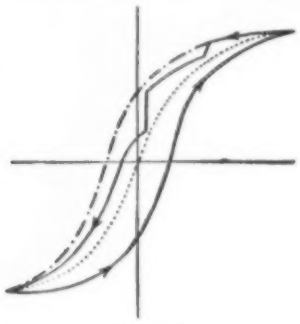


FIG. 13.

herers, which relapse of themselves into a condition of non-conductivity, thus rendering a tapper unnecessary. The microphone-receiver (see Prometheus xiii., p. 442) belongs to this category. An apparatus sometimes made use of in Italy, the Castelli coherer (Fig. 9), which permits of the use of a relay, consists of a glass tube in which two carbon electrodes are introduced; between these and separate from them is a short iron cylinder; in each gap there is always a drop of quicksilver. Of this type, too, there is a number of varieties.

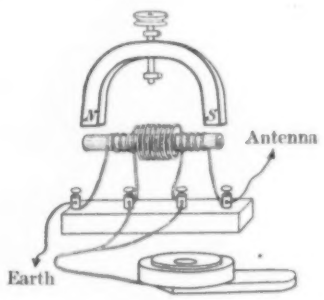


FIG. 14.

The Schäfer plate and the Neugeschwender anti-coherer belong to this group. A glass plate is overlaid with a thin coating of silver, which is divided by a narrow slit. As a rule this plate conducts fairly well if it is included in a circuit with a galvanoscope and a battery cell (Fig. 10). Should electric waves, however, interrupt the microscopic connection between the two layers, the current diminishes through the increase of resistance and the galvanoscope gives a weaker deflection. The resistance resumes its former weak condition through the formation of new bridges.

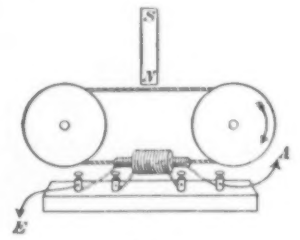


FIG. 15.

The second group has only a few examples. The best known is Fessenden's detector. An extremely thin platinum wire is inserted in the circuit instead of a coherer. If excited electrically, it becomes heated; and this heat increases the resistance of the wire and can thereby be indicated, or it expands the air in an air thermometer (Fig. 11) and from the displacement of a column of liquid we can deduce the amount of the excitation.

Before we can understand the operation of the de-

FIG. 16.

FIG. 17.

tectors of the third group, of which Marconi's magnetic detector is a practical example, we must understand a peculiarity of iron demonstrated by magnetization, known as "magnetic hysteresis."

We will take a soft iron rod and magnetize it by placing it in a coil of wire through which flows a slow alternating current. As the current increases in strength, the magnetism of the iron will increase. We will show this graphically by a curve, along the horizontal axis of which we indicate the current values, while the resulting magnetization is indicated along the vertical axis. With the intensity a (Fig. 12) the magnetism is a'; with the intensity b it rises to b', etc. Now reduce the strength of the current and the magnetism really should decrease in the same degree; therefore the strength of the current b should again produce magnetism b'; but this is not the case; on the contrary, the magnetism begins to decrease at first

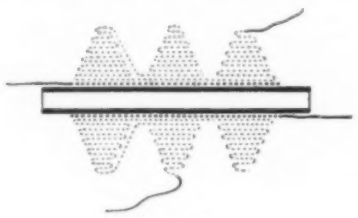


FIG. 18.

more slowly, so that b produces magnetism b''. The descending curve takes another direction from the rising curve. We say: Magnetism depends on the previous condition of the iron; it varies with the degree, o, of magnetization to which the iron has previously been subjected. If the iron had no coercive force the ascending and descending curves would be identical and would lie midway between the present ones, as shown in Fig. 13. The electric waves have a remarkable property of preventing this displacement of magnetism above and below, so that at the same moment that the waves surround the iron, the magnetic conditions vary and approach the values which would have resulted but for the molecular inertia of the iron. In the cut two such sudden variations in the hysteresis are indicated.

The magnetic detectors uniformly utilize this property of the waves. Fig. 14 represents one form. A bundle of soft iron wire is wound with two thin wire coils. The ends of one coil are connected with the ground and with the antenna, the ends of the other with a telephone receiver. A permanent steel magnet, $N\,S$, is rotated slowly by means of an electric motor or clockwork, and by this means the bundle of iron wire becomes variably magnetized, as we saw before. Should the waves pass along the inner coil, however, the magnetic condition of the wire bundle suddenly

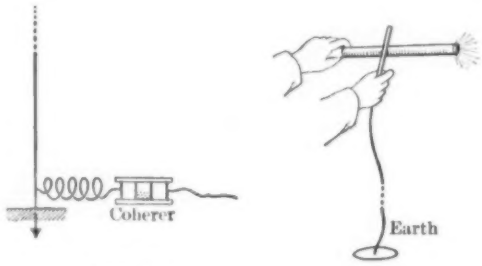


FIG. 19. FIG. 20.

changes, and a current is induced in the second coil, which makes itself perceived by a crackling sound in the receiver. In another arrangement (Fig. 15) the magnet, $N\,S$, is at rest, but a thin endless iron wire cable is pulled across it, so that it is still weakly magnetic. It moves through the two wire coils, which are connected as before with the antennæ A, earth E, and the receiver. Both forms are very sensitive and reliable, but have this drawback that they require a rotating force and permit only subjective reception of messages.

The fourth group is free from these objections, but it depends on quite different principles. Schlömilch uses as a detector a jar of weak sulphuric acid, in which two platinum electrodes are dipped (Fig. 16). The one connected with the positive pole of a 6-8-volt battery has only a tiny surface in contact with the solution. It consists of a platinum wire about 0.01 millimeter thick, fused into a glass tube, so that only the cross section of the wire touches the liquid. Such a cell has usually a very great resistance; on the passage of electric waves, however, the resistance decreases very considerably, and then of its own accord regains its former strength. Schlömilch also dispenses with the auxiliary battery when he selects as elec-

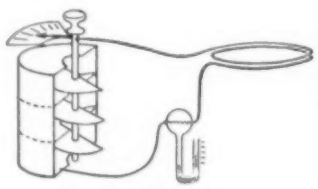


FIG. 21.

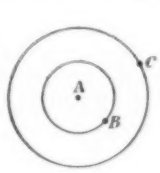


FIG. 22.

trodes two metals of different values in the electromotive series, so that the cell itself forms a small galvanic element. The effect on excitation is similar. It was at first surmised that it was owing to a thermic action in the detector, similar to that in the Wehnelt interrupter. But as Reich has shown, and as I have demonstrated by experiment, the action is of a purely electrolytic nature. If one prevents the small electrode from becoming covered by polarizing coating, at the same time dipping a small copper electrode in a copper sulphate solution and a strip of zinc in a solution of common salt and water (Fig. 17), the cell will generate a fairly strong current which diminishes on excitation. If the copper electrode is drawn up into the salt solution, a weak current will be induced by polarization, which becomes stronger on excitation. There can thus be in the same cell the action of the coherer and anti-coherer.

We will here leave our review of the detectors and make a few remarks concerning two appliances of the receiving station which serve the purpose of making the incoming waves more especially adapted for the indicator.

One of these apparatuses is the well known "jigger" of Marconi. Finding that the coherer he used responded in a less degree to the intensity of the alternating currents induced in the receiver by the incoming waves than it did to their tension or voltage, he transformed the resulting current to the desired tension by means of a special little transformer, which he called the "jigger." Fig. 18 shows the section of such a transformer.

The other apparatus, constructed by Slaby, called the multiplier, has already been discussed in Prometheus. As an improvement has been made upon this, universally practical for wireless telegraphy, we will consider it briefly.

We have already repeatedly considered the equation $\lambda = 2\pi\sqrt{L\,C}$, and can deduce important conclusions from it. It offers us a fresh manipulation. Our aim is to convert a certain amount of vibratory electrical energy so as to obtain the highest possible tension. If we have a large capacity we can charge the system with a high degree of energy, without reaching a high tension, as we have already shown. We must then take the smallest possible capacity, in order to receive a high potential from a relatively small amount of energy. λ must remain unchanged and we must correspondingly increase L considerably. L, the self-induction, the induction of a conductor upon itself, can easily be increased, if it is wound a great number of times; the separate conducting particles thus approach each other closely and act on each other strongly. C must be small and a thinner wire answers for this purpose. If we have one of these coils (Fig. 19) and fasten it to an antenna with the same λ, it will be compelled to oscillate syntonously, but its energy is separated into other components, the intensity is reduced, the tension greater than before. This is what we sought to attain.

We have always said that any part of a plant, if syntonic with any other, must have the same vibrating frequency. How do we become aware of this syntonic condition which is so universally important for the working of the apparatus? The principle of the multiplier shows us a very easy way, for it allows us to determine the length of the waves produced by the oscillation. If we bring a multiplier coil, perhaps a glass tube, wound with a layer of very fine copper wire (0.1 millimeter) into proximity with a vibratory system, it will be excited to oscillation. This mutual vibration will be the stronger—according to the principle of resonance—the greater the similarity of the frequency of vibration of the exciting system and the multiplier rod. If one changes the free vibratory end of the coil, by sliding a grounded metal rod (Fig. 20) along its length, the vibration period of the coil will also be changed, and this change need be continued only as long as the coil is in resonance with the excitation. That this is the case is shown by the spark-brush, induced by the high tension, or through the illumination of a plate coated with barium-platinum-cyanide, etc. Such a rod which has a scale, corresponding to its length, can be gaged as a meter measure and permits one to determine—with the necessary precautionary rules—the vibratory conditions of a system.

A second apparatus, worked out by Dönitz, can be applied in the same manner. It consists, like the multiplier wire, of an oscillatory system, but in this case L is not changed in the adjustment of the resonance, but C, the capacity. By means of an arm, connected with an index dial, the relative positions of the segment-like plates of an air condenser can be so changed that a wave detector of group 2 can indicate the maximum of excitation. In order to increase the scale of the apparatus, the self-induction coil with which the apparatus is loosely coupled to the vibratory system, as seen in Fig. 5, can be changed.

Finally, we will give a short summary of methods, by means of which the secrecy of the message can be secured, and it will eventually become practicable for several stations to be simultaneously placed in connection without interfering with each other. The resonance principle is most generally used in practice, the syntonic electric telegraph; and indeed this renders possible the communication between opposing parties in times of peace. But there have been many other experiments, which, however, have so far been of little value.

If we consider the radius of action of the transmitting station on the earth's surface, with reference to the receiving station, we can differentiate about three groups:

1. The radius of action lying in a horizontal plane: (a) Electrical syntonism; (b) mechanical syntonism.
2. Linear radius of action.
3. Zone shaped radius of action.

Group 1 a is decidedly the most important and has already been sufficiently discussed. 1 b provides an

apparatus which connects up the receiver periodically for only a short time. Should a dispatch be given at such a station, the signals must be sounded during exactly the same period that the receiver is connected. This is made possible by a synchronous apparatus. A series of stations "whose sensitive moment" is almost identical may in this way carry on a communication without influencing each other.

Group 2, by working with short waves (Blochman, for example, 20 centimeters) which can be made parallel with lenses or looking glasses and radiated toward the receiving station. This purely optical method has this disadvantage, that as grounding must be avoided, and short waves are more readily absorbed, it has a very limited field of operation. In this group we can also include Guarini's relay stations, which combine an ordinary receiver and transmitter in one apparatus, so that a signal from a distance is automatically repeated and transmitted. A line of similar relay stations would render possible a kind of linear propagation.

Group 3 comprises the systems in which it is endeavored to perfect the method by which only one receiving station at a certain distance from the transmitting station shall receive the message. In times of war one might do this in the following manner: If one wishes to telegraph from *A* to *C* (Fig. 22), without *B* being able to decipher the message, one places two apparatuses in *A*, one large, which reaches to *C*, and one small, which reaches only to *B*. By sending a message through the larger apparatus to *C*, at the same time that the smaller apparatus is working, the receiver at *B* gets only a mutilated dispatch. Another construction, proposed by Jégou, provides the receiving station with a large and a small antenna, whose coherer circuits influence a galvanoscope in opposite directions. If the station is in close proximity to the transmitting station, the small antenna receives powerful waves, the two coherer circuits approach each other and the galvanoscope does not deflect. If, however, the stations are at some distance, the circuit of the larger antenna becomes stronger and the galvanoscope deflects. The proper relative length of the antenna is determined by the given distance.

If these are not all the suggestions or improvements of later years, they are enough to give an idea of the present status of wireless telegraphy. The coming years will be fruitful in improvements and in inventions, and it cannot be long before we take the next step forward and, in addition to wireless telegraphy, render possible a wireless telephone system by means of electric waves.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

[Concluded from SUPPLEMENT No. 1536, page 24615.]

HIGH-SPEED, LONG-DISTANCE ELECTRIC TRACTION.*

By CHARLES A. MUDGE.

THE transformers, which weighed 3½ tons each, were mounted on either side of the center line of the car body just behind each truck; and a line connecting their centers of gravity did not coincide either with the transverse or the longitudinal center line of the car. This gave rise to a torsional movement, which produced a dangerous swinging of the car when running above the speed referred to, which was overcome by placing weights of about one ton each on the side opposite to that on which the transformer was mounted. The fact was thus confirmed that heavy pieces of apparatus should be mounted in the center lines of the cars for high-speed service, as they run smoothly only when their weight is equally distributed upon the wheels.

All apparatus above the car floor should be light. This applies particularly to the trolley construction. If the trolley for high-speed work is to be of a light construction, which is the tendency of most designs abroad, particular attention must be given to the form of the exposed surfaces, on account of the high air pressure, and means must be applied to counteract it. When the current is collected at the side of the car, as in these experiments, any slight swaying of the car is at once felt by the trolley, and the higher the current collectors are placed from the ground, the greater is this disturbance. Also, the trolley wires as placed in these tests were very sensitive to cross winds, and even to the slight pressure of the sliding bow against them, necessitating spacing the supporting poles closer together than they were originally placed, and stretching the wires themselves with very high tensions.

Passengers in the car could hear very distinctly the click as the trolleys passed over each support, showing that they received a slight blow at each of these places, detrimental both to the trolleys and to the insulated supports.

In this construction of trolleys it is of the greatest importance at high speeds that the lateral swinging motion of the car should be transmitted as little as possible to the trolley; and there must be considerable flexibility between the trolley base and its contact piece, so that this piece can follow the trolley wire independent of the motion of the trolley base.

Through the experience gained with this type of trolley it would seem that the current could be better collected above the car roof instead of at its side, in which case it does not matter if the motion of the car is transmitted to the trolley. In fact, if the bow form is used, it would be desirable.

But then we run into the trouble and expense of supporting the trolley wire so that it does not sag, which is more essential at high speeds than at those used at present. For these tests, however, on account of the high voltages used, the necessity of three conductors, the cost of installation, and not having the experience of the catenary form of suspension, the trolley line construction used to serve the purpose very well, and it is doubtful if any other would have given better satisfaction. In this connection, it may be interesting to read a few notes from the log I kept during the tests:

Monday, October 12, 1903.—Cold and windy; rained throughout the night; rails wet. Left barn at 9:30 for Zossen.

35 periods—11,000 volts. Max. speed 140 kilometers.

After leaving the barn, wagon was stopped about ½ kilometer out to see if trolleys were working right. Pressure and adjustment O. K., started up at 500 amperes per motor. Took the first 2,000-meter curve at 100 kilometers, then ran up to 138 kilometers. Trolleys acted fairly well except in taking curves, when they would leave the wire. Sometimes on level they would also leave the wires, on account of swinging of the car, as well as swinging of wire itself caused by the wind.

Got to Zossen without accident. Waited 15 minutes, then started back. All went well until about 6 kilometers from shed, when one trolley was torn away by catching into insulator. This seemed to have broken the overhead work as four other trolleys were immediately torn loose, leaving only one (upper B. end) intact. Cut out all apparatus and coasted into shed from 120 kilometers speed. As soon as we got out of the car our first impressions, after looking toward its top, were that the trolley question was not any nearer a solution than before.

The idea of having the trolleys on six separate poles does not seem to be the best. The scheme of two poles might be better, as the trolley bows would lie directly above each other, and in taking curves and supports they would all strike together, making it easier to keep on the wires as the car turns. This may necessitate stronger supports as the blow from the trolley would be much greater, being all delivered at the same instant, instead of one after the other, as is the case with our construction. This construction is not good, on account of having three separate poles connected through worm and gear, and supposed to turn in synchronism; but due to the play and wear in gears they do not press the bows on the wires with the same degree of intensity. One will be pressed hard upon its conductor, the second not so hard, and the third possibly not at all. The method of adjusting the trolleys is not good, as they cannot be seen when being turned toward the wire. It would be better if a port hole, through which one could see all trolleys, were arranged, and if adjusting wheels were placed near at hand with a signal bell to the driver, instead of trying to make him do the work of two men.

This suggests some of the trouble we had before getting the trolleys to work properly, much of which might have been avoided if it had been possible to place the contact wires above the roof of the car.

If the motors are direct connected to the axles, a part, at least, of their weight should be flexibly connected to it. Motors of this power—250 horse-power, normal rating—run into weight, and, both on account of the permanent way and the truck, as much of their weight as is possible should be flexibly supported on the axles. This flexibility need not be great, and can be through the medium of heavy springs. There is a certain oscillation given to all the parts on a car moving at such high speeds, and it often occurs, through the unevenness of the roadbed, or slight inequalities in the rails; or the motion of the car itself, that a certain oscillation of a heavy piece of apparatus will be met out of step. For instance, the motor will be going down just as a part of the rail is coming up, and a severe blow will be the result. A little flexibility of these parts will greatly reduce the force of this blow. At speeds over 100 M. P. H. it very often seems as if the rolling friction were taking a rest, and that we were actually floating for short distances, after which we notice very distinctly that gravity has not forsaken us, and we can almost hear the rails groan under their extra burden.

It is at such times that the flexibility of the apparatus is mostly needed; not so much when we pass over the rail joints or frogs, as the car doesn't take much notice of them, and is far beyond before their effects could be felt; but just at those moments when the apparatus seems to be furthest out of synchronism with the car.

Since it is impossible to build an absolutely level and straight track, we can help conditions very much, as well as increase the comfort of passengers, by having heavy pieces of apparatus flexibly supported in the car.

Giving the car a wedge-shaped construction may not be possible when using the vestibuled type with multiple unit control, and no definite end relation, in which case it may be advisable to have a portable wedge-shaped engineer's cab on wheels, capable of being quickly attached to the front of the car in making up the train.

We found that it was a very good thing to hold the car body firmly to the truck frame at points equally distant from the center pin, also to allow it a movement independent of the truck, parallel with the axles. The trucks take curves much more quickly than the heavy car body, which requires a certain amount of time to swing it out of its straight line path, and should not be attempted too rapidly.

It should not receive a blow to turn its nose in the new direction, but a gradually increasing pressure until it is turned out of its former course. This was very well accomplished by the center pin bearing being mounted flexibly in the truck. The pin was held in its middle position by 1½ tons pressure, and could be moved out of this position for 1 3/16 inches to its furthest limit, by the addition of about 2¾ tons pressure. This had the effect of swinging the car body more gradually into the direction taken by the trucks, and the shock was considerably less than that experienced with the trucks used in the first year's tests.

If we build our roads with few curves, we might as well take full advantage of the fact, and make our wheel base long. The 30 per cent increase of base in the truck used in the last year's tests was a noticeable improvement over that used in the previous tests. With a greater distance between wheels we have a better chance to equalize the weights upon the axles, since the lever arms and springs between them may be made longer and consequently more sensitive and easier to adjust. In three-axle trucks the motors will most likely always be mounted on the outside axles, making it necessary to carry a greater percentage of the weight of the car body on the middle axle, than is carried on the outside ones.

As this weight fluctuates considerably this fact must not be overlooked in designing the equalizing lever arms of the truck, as otherwise the load will be unequally distributed on the axles and possibly disturb the smooth running of the car.

The track used for these tests was built at a greater distance from the main line track than is customary to place parallel tracks in this country, and consequently the air pressure effects of trains moving in opposite directions, as well as in the same direction, could not be observed very closely. It was evident, however, that there was a slight disturbing influence in the smooth running of the car whenever it passed another train. What this would have amounted to if the tracks had been placed nearer together it is impossible to say, but it is a point that would have to be considered in building new lines, and would suggest placing the tracks further apart than is our present practice.

The two curves of 1¼ miles radius were built with an elevation of 3¼ inches of the outer rail, the approaches of which were 165 feet long, according to the standard practice of the State railways. These approaches were found to be too short, as the car gave a decided lurch in taking them when traveling over 90 M. P. H.; so they were increased to 330 feet, or twice their original length, after which the car rode over them smoothly.

These are some of the important points brought out during the tests, which will be of great assistance to engineers and designers working along similar lines; and just at this time, when the conversion of steam roads to electricity is commanding so much attention, the subject of increasing the speeds of travel is most pertinent. There is no doubt whatever that speeds as high as 100 M. P. H. can be used with absolute assurance of safety. It may be necessary to adopt a signal service somewhat different from those at present in use, as in traveling at these speeds it is more difficult to recognize colors and to distinguish the forms of objects than at lower speeds.

In passing stations at 125 M. P. H. it was not possible to recognize persons standing upon the platforms, and only those at a distance of 50 feet and over could be approximately identified. On dark and rainy days it was quite impossible to read signals at this speed, except when of large dimensions or of very pronounced color.

This would suggest placing the signals in the car itself, operated electrically either by direct contact or through inductive means. Such a system was tried at Zossen and worked perfectly, even at the highest speeds.

An insulated piece of angle iron was placed alongside of the rail, it and the rail constituting two poles of an electric circuit. As the car passed over this section contact was made with the angle iron by a brush which led current through a magnet in the car, releasing a spring and allowing a disk to fall in front of the motorman, the circuit being completed through the wheel.

A system on similar lines could easily be arranged to ring different bells, or to operate different colored disks in the engineer's cab, thus relieving him of the strain upon the eyes caused by passing so many objects which naturally distract his attention.

In all the runs, of which over 300 were made, no difficulties were met with, or even suggested, that the skill of the engineer did not or could not overcome; and this great triumph, in a branch of industry which has done more than any other to lift the human race to a higher degree of intelligence, should serve as a stimulus to us, who are anxious to have trains in regular service running at this, the highest speed ever attained by any device used for human transportation, 131 miles an hour.

Following the address an interesting discussion ensued.

Mr. Sprague, president of the society, stated: It seems to me that there are two questions suggested by the Zossen experiments:

(1) To what extent will the commercial possibilities warrant speeds anything like those attained?

(2) Assuming that for long distances alternating

* Address before the two hundred and fifty first meeting of the New York Electrical Society, held on May 24, 1905, in this city. Mr. Charles A. Mudge was formerly chief engineer of the Railway Department of the Allgemeine Elektricitäts Gesellschaft, Berlin, which took part in the noted Berlin-Zossen trials.

current be used, shall it be by the polyphase method, as at Zossen, or in a single phase development?

One thing must strike everyone who has followed Mr. Mudge's most interesting description, and that is the extraordinary difficulties which had to be met, and the great increase of power as the speed approached the higher marks. My own impression is, taking into account all the practical conditions surrounding trunk line construction and operation, a maximum speed of about 100 miles an hour is all we can reasonably, for a time at least, try to reach. Not that cars cannot be operated at higher speeds; but the difficulties which must always stand in the way when we take into account all the essentials of trunk-line operation, seem as yet to hardly warrant the commercial use of such speeds. This is a feeling which I have had for a number of years, and I believe it is one which is generally shared by both electrical engineers and steam road operators whenever they have fully studied the matter.

These conclusions, of course, do not vitiate or belittle in any sense the importance of the experiments which have been made; because, in order to operate even at 100 miles an hour as a maximum it is desirable to make trials at much higher speeds; not only to develop weaknesses of apparatus, but to clearly indicate the practical working difficulties and limitations which confront the engineer.

Mr. Mailloux remarked: It seems to me that these tests prove all that was intended. In regard to the selection of systems when it comes to traveling over 50 miles an hour electrically, while it seems as though we should use some alternating system, I am not prepared to say which should be used. The single phase has

CATCHING A 50-POUND SNAPPING TURTLE.

not yet been developed to sizes which will do what the large polyphase motors can do. Before we can authoritatively say what would be the best method, further experimentation will be required. I do not think that that point will be reached immediately. The experiments now being made on the New York Central and Pennsylvania roads will give us some valuable data. I am not prepared to say, and I don't think any person is, that they will bring about any real general solution. They are, in reality, what mathematicians term "particular solutions." We have something to learn before the electrification of steam roads in general is an accomplished fact. We shall have to proceed gently. I do not wish to be understood as being pessimistic. I believe it is going to come; but by evolution rather than by revolution; not to-morrow, or in 10 days, nor, possibly, in 10 years. I believe there will still be steam locomotives 25 years from now. The subject is of the greatest interest; and it is a rare treat and a great privilege to be allowed to listen to such a presentation of the subject as has been made this evening. I was fortunate enough to receive a copy while in Berlin of the official report referred to by Mr. Mudge, and also copies of articles contributed by Dr. Reichel. They did not show or divulge so much information as Mr. Mudge has done.

Mr. Sprague: I quite agree with the general statements which have been so clearly made by Mr. Mailloux. We are not on the eve of the general conversion of steam-operated roads, despite the somewhat roseate predictions of the junior Senator of New York, Mr. Depew, who relegates the steam locomotive to the scrap heap during the next ten years. His prophecy was doubtless largely influenced by the character of the work which is being done in New York by the great terminal lines, with one of which—the New York Central—I am actively connected, for here all the speed and power which are acquired on the heaviest steam locomotives are more than duplicated by the electric locomotives now under construction, and the first of which is being thoroughly tested. I may say, in passing, that this locomotive, which weighs about 100 tons, and has 71 tons on the drivers, has been designed and built by the General Electric Company and the American Locomotive Works, and being a radical departure from some ideas heretofore considered essential in motor construction, is a remarkable product, when we consider the short time of its development and what it has already accomplished.

It is interesting to note that some of the difficulties met with on the Zossen line at high speeds were encountered in the earlier tests on this locomotive. Notwithstanding the fact that it had leading trucks, there was a distinct "nosing," caused by lateral sway, which was periodic, i. e., corresponding to the length of the rails, and resulting in some displacement at 30 feet intervals. It was thought, at one time, that possibly the low center of gravity was the cause of this; but this, apparently, did not prove to be the case; for, by using side springs, and subsequently, in addition, friction plates, to retard the free action between the body of the locomotive and its pilot trucks, this "nosing" was made to entirely disappear, even when traveling at the rate of 82 miles an hour. Had the potential been raised, I have no doubt that speeds of between 90 and 100 miles an hour could have been easily made.

Speaking, however, of the general problem, we must bear in mind that what is being done in New York relates to congested terminal operation, and there are many local conditions which have dictated the use of electricity without necessarily putting it on all points on a directly competitive basis with steam operation. One of the earliest applications of electrical operation on miscellaneous roads is likely to be due to the recognition of the fact that in many cases the concentration of grades and electrical operation, in whole or in part, at such grades, may prove cheaper than the making of costly detours. In such cases, both continuous and alternating current motors can be used, and which shall be the better is a matter to be decided by local conditions. In spite of the admirable work which has been done abroad with the polyphase system, and granted its possible desirability in certain special cases, I cannot but feel that, speaking generally, the multiplicity of conductors will stand as a bar to any general application to trunk line service, and that the later developments in single phase operation offer, on the whole, more promise of final adoption, where alternating currents are used.

Mr. Shepard, of the Westinghouse Company, said: We have a locomotive in operation at East Pittsburg, upon a specially equipped track, about four miles long. We last week put this locomotive in operation, pulling a 50-car freight train, for the benefit of the visiting members of the International Railway Congress. This locomotive is designed for the heaviest work. Its weight is 135 tons, its capacity 1,600 horse-power, the maximum drawbar pull being 80,000 pounds. This has been registered on the tests already made. The overhead construction is the catenary type, and the voltage in use is 6,600. The control of this is by induction regulator. This is quite the ideal control for such service. The tests demonstrate fully the practicability of the single phase motor of this capacity. The results were fully up to expectations. The tests seem to show that this type of locomotive will find its field in heavy service where concentrated powers are required, as, for instance, on pusher grades, which under steam service are most expensive to operate. In order to secure concentrated power with electrical operation the track conditions need be no more severe than for comparatively light steam locomotives—this by reason of the facility for distribution of the motive power over different axles. I agree with Mr. Mailloux and Mr. Sprague that the adoption of electricity on steam railroads will be gradual; at first, in such special applications as this locomotive is fitted to meet, and such terminal propositions as local conditions determine; and, ultimately, the expansion of these installations will be quite readily accomplished where the high voltage single phase system is used.

THE SNAPPING TURTLE.

TURTLES and tortoises are peculiar creatures which are not exactly in harmony with present conditions. Among their larger forms are animals that recall a remote past, "antediluvian creatures," in which the intelligence of the animal has not yet become the preponderating influence in assuring the preservation of the species, but each individual is made invulnerable by a bony shell or coat of mail. These reptiles, in fact, played an important part in primordial times, and their petrified remains are abundantly known to science. A celebrated deposit of these prehistoric turtles is that of Solothurn, in Switzerland, where several hundred shells and fragments of shells belonging to fourteen distinct species have been found within a circumference of less than a kilometer. The largest species that ever existed was the mammoth turtle of the Himalayas, the carapace of which was four meters long and nearly two meters broad. This species lived in the tertiary or brown-coal period. In comparison with it the still living giant land tortoise of the Galapagos Islands (*Testudo elephantina*) is a mere pygmy.

The peculiar anatomical construction of tortoises and turtles has always excited the wonder of man. In these creatures the internal skeleton characteristic of vertebrates is brought, for the most part, to the surface, where it is merged into the cutaneous skeleton, forming a thick, bony case into which the animal withdraws when alarmed. The Chinese aptly denote this singular anatomical conformation in their names for turtles—*uny-ko* and *uny-jo*—which may be roughly translated "bones outside, flesh inside." The bony carapace of a large and old turtle is so hard and strong

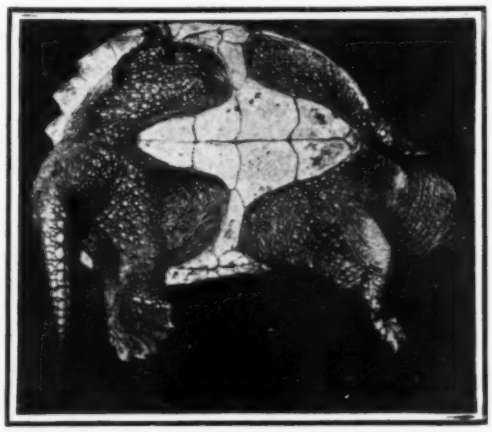
A YOUNG SNAPPING TURTLE.

that the animal may be run over by a wagon without injury.

Of the known species of tortoises and turtles, about 225 in all, more than 150 are inhabitants of the tropics. The greatest variety is found in the Americas, where there are ninety species. Species which live in marshes predominate largely in the southern and eastern parts of North America, and to a smaller degree in Central and South America.

The marsh tortoises, in general, are more intelligent than the land tortoises. The mere fact that they are not vegetarians, like the latter, but feed on various animal creatures which they are compelled to hunt necessitates a higher development of the organs of sense. On the other hand, they are also more timid and wary than land tortoises and they display cunning and strategy in hunting their prey. The various methods employed by the snapping turtle to secure its booty may be studied without difficulty after the animal has become accustomed to captivity. At one time it crawls slowly and silently with neck outstretched toward an unsuspecting fish, springs upon it by a powerful thrust of the hind legs and snaps it up; at another it drives the fish around the basin and terrifies it until it falls an unresisting victim. Again, the reptile may be observed buried in the sandy soil of its prison with only its bill and eyes protruding. On the approach of a fish the head and long neck dart forth from the sand with lightning speed and the prey is caught and instantly killed by a bite in the abdomen.

In the wild state the snapping turtle is distinctly a nocturnal animal. After sunset it crawls out of the mud of the pool, in which it has passed the day, to hunt by land and water. It moves quite rapidly through the water as well as over the ground and sees very keenly in twilight. Cunning, shy, and suspicious, it detects the slightest threatening ripple on the surface of the water by means of the highly developed tactile sense of its cutaneous papillæ and hence it is not easily captured. In the actual presence of danger it becomes bold, defiant, even desperate. When driven to bay it retracts its neck, head, and widely gaping jaws into its shell and awaits a favorable opportunity to thrust them forth slyly and bite savagely. Anything which it has seized in its jaws it holds with wonderful tenacity, at the same time fiercely scratching the earth with its sharp claws. The jaws of the snapping turtle are so strong that it can easily bite through a stout



THE SNAPPING TURTLE—VENTRAL VIEW.

cane. It can be grasped and lifted with impunity only by its long tail.

In North America, where the snapping turtle is found from Canada to Florida and Alabama and as far west as Missouri and Louisiana, it is eagerly hunted for its very palatable flesh. It is caught most easily in the breeding season, when it betakes itself to the land and lays its eggs in conical holes in the sand. The hole is dug with the hind feet, and after the eggs have

been laid, the earth is drawn over them with the fore paws and smoothed by pressing with the under shell or plastron, and they are left to hatch unaided.

The egg has a calcareous or parchment-like shell and a large, orange-colored yelk, surrounded by a thin layer of greenish albumen. It is said to be very palatable, but I cannot confirm this statement from personal experience, as I have never had an opportunity of tasting it.

The young turtles emerge from the buried eggs in a few months. The snapping turtle is a formidable beast of prey in the swamps and muddy streams in which it abounds. Not only do fishes and frogs fall victims to it, but it carries off ducks and young geese and, as it is extremely voracious, it may work great havoc in farms where water fowls are raised. It seizes the birds by the legs and drags them to the bottom of the pond where it tears them to pieces with the aid of the long claws of its fore paws and devours them under water. Few marsh turtles are able to consume their prey on land, and these do so with evident difficulty. All species, as a rule, require the aid of water. In the act of eating they take water in short but vigorous gulps, and thus the morsels torn off by the claws are washed down into the gullet where normal swallowing begins. Young snapping turtles are now kept in terrariums by many amateur naturalists.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Vom Fels zum Meer.

EXPLORATION AND SURVEY IN TIBET.

By the English Correspondent of SCIENTIFIC AMERICAN.

AN interesting lecture was recently delivered before the Royal Geographical Society of Great Britain by Major C. H. D. Ryder, R.E., who was in charge of the survey department attached to the recent British expedition to Lhasa. The work which was carried out by this official is of a momentous character, and constitutes an invaluable contribution to our geographical knowledge of this hitherto closed country. Major Ryder, as a reward for his careful work in this connection, has been decorated, with the approval of King Edward VII., with one of the Royal Geographical Society's highest awards—the patron's gold medal. The paper dealt with the exploration and survey of Tibet from Gyangtse to Simla *via* Gar-Tok.

Prior to the British mission, the geographical information concerning the country lying between India and Lhasa depended chiefly on the surveys executed by native explorers attached to the India Survey Department. Now, however, these rough maps have given place to an accurate survey of the country traversed by the British mission.

From Kamba Jong, where the mission was encamped during the latter months of 1903, or rather from the hill above it, one continuous line of snows was visible, stretching from Chumalhari to Mount Everest, a distance of some 150 miles. Surveying extended from this snowy range northward to the watershed between the Arun River and the Tsang-po. As regards the heights of the peaks, the results were negative in character, none being found to approach the height of Mount Everest. The instructions to leave Kamba Jong and advance up the Chumbi Valley fortunately came just when all the surveying possible had been completed. Major Ryder found the Chumbi Valley disappointing. It had always had a great reputation, but proved to be only 200 or 300 yards wide and not very rich. From this base one of the native assistants completed a most useful piece of work, covering a hitherto unsurveyed portion of Bhutan.

On arriving at Lhasa, Major Ryder in company with Capt. Cowie undertook a survey of the town and the suburbs on the scale of 6 inches to the mile. The height of the plane above sea-level worked out at 11,830 feet. Afterward useful trips were undertaken in the neighborhood of Lhasa, including one to the Pen-bo La, where he succeeded in effecting a satisfactory connection between the triangulation done from Gyangtse and that done at Kamba Jong in the previous year. When the main body left Lhasa, new routes were followed to Gyangtse. A detour from Yamdok Tso by way of a continuation of the Rong Chu Valley was important, showing the possibility of turning the Karo La. Arrangements were made for Capt. Cowie to continue the survey work on the return march from Gyangtse to the Chumbi Valley, while Major Ryder went with the western expedition.

The survey results of the mission, exclusive of those obtained on the western trip, were as follows: The triangulation was completed of an area of 45,000 square

A CAPTURE.

miles, connecting Lhasa with India, and fixing all prominent peaks which were visible, with their heights. Seventeen thousand square miles of country were surveyed on the scale of four miles to the inch, of which 3,000 square miles in the neighborhood of the Chumbi Valley, Gyangtse, and Lhasa were also surveyed on the scale of two miles to the inch. Route surveys on the scale of one inch to the mile were made of the road to Lhasa. Finally, large-scale plans were constructed of the towns of Gyangtse and Lhasa.

When the treaty was signed at Lhasa on September 7, 1904, it was decided that a party should proceed to Gar-tok to examine that place, which was one of the trade marts which the Lhasa government had agreed should be opened in Tibet. The survey party consisted of Major Ryder, Capt. H. Wood, R.E., Sub-Surveyor Ram Singh, R.S., and a number of other native assistants. The first day's march from Gyangtse, where the expedition was organized, took them to Dong-tse, the late headquarters and supply depot of the Tibetan army, which had attacked the mission and its escort for two long months at Gyangtse during the march to Lhasa. Three more marches, following the valley of the Nyang Chu, which was one of the richest and most prosperous valleys of Tibet, landed the party at Shigatse. While at Shigatse the great Tashi Lhunpo monastery was visited. The monks received them most cordially, showing them all over the place. This monastery was said to contain 4,000 monks, and though not so large as the great Lhasa monasteries, was richer. Bogle's description, written more than a century and a quarter ago, was found to be very accurate. The number of tombs of previous Tashi Lamas had, however, increased in the interval from three to five.

The party also paid a visit to the present Tashi Lama, who, after holding a position almost coequal with that of the Dalai Lama, had now, by the deposition of the latter, become the most important ecclesiastic in Tibet. The Tashi Lama was an interesting personality. He was the sixth holder of the office. His age was only about twenty-three, but his quiet, dignified manner made a lasting impression on them. He seemed to be generally loved and revered.

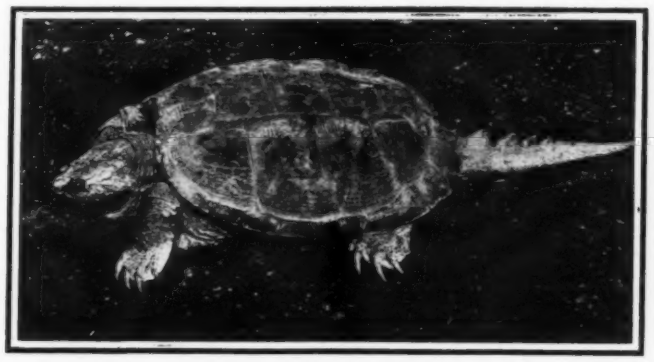
The surveyors had begun work at Dong-tse, one march from Gyangtse, and as they wished to keep up the triangulation, Capt. Wood and himself left Shigatse on October 17, the rest of the party following a day later. The triangulation was carried on under very adverse circumstances. To climb one of these hills was itself a hard piece of work: to take observations at the top in a bitter wind was one of the most physically painful operations that were experienced. To do this in combination with a day's march led to a very long and hard day's work. Capt. Wood carried this on for days and months, with hardly any intermission. Major Ryder then journeyed westward up the valley of the Tsang-po, or Upper Brahmaputra, close to which river Shigatse is situated. The attitude of the Tibetan was invariably friendly, and under these circumstances the expedition from time to time ventured to divide, thus materially increasing the value of the geographical work accomplished.

On November 1 Major Ryder and Capt. Rawling ascertained that the river ran between rock hills with snow peaks on either side. It was found necessary to make a wide detour to the south. From one height they had a magnificent view of the main Himalayan range. Mount Everest stood up, towering above the rest of the range in its neighborhood, in one isolated peak, a continuous drop of some 8,000 feet separating it from the rest of the range, east and west. A little later Mayor Ryder made a side trip and obtained an uninterrupted view of Mount Everest, no hills intervening, and was able satisfactorily to establish the fact, which he had suspected a year before at Kamba Jong, that no peaks approaching the height of Everest exist to the north of it or anywhere in its neighborhood. The Tsang-po was reached again on November 5. The scenery was now changing. Trees had been left some marches back; that day they passed the last signs of cultivation, while the hills became more open, and the plain abounded in sand-dunes. During the whole portion of this river journey no four-footed game was seen other than numerous hares and a few gazelle on the Su-tso-tan plain, but birds were seen, and Tibetan partridge, ramchikor, and the otherwise monotonous fare of mutton. On November 6 the party crossed to the north bank of the river by the rapid current.

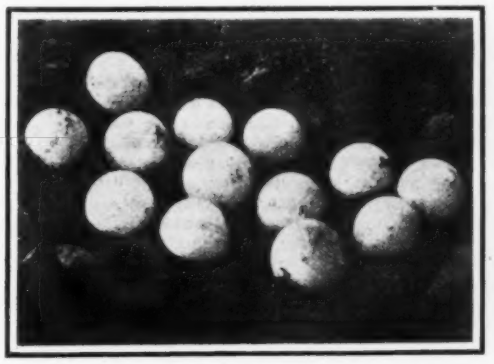
Meantime, a party under Capt. Wood and Lieut. Bailey had been traveling on the north side of the river, traversing the watershed between the Tsang-po and its large tributary, the Raga Tsang-po. The valley of this latter stream was narrow, running almost due east and west, parallel to and about 30 miles to the north of the main river. Into this distance was crammed a tangled mass of hills, whose crests averaged about 18,500 feet, with several peaks of about 22,000 feet covered with perpetual snow.

The parties were united at Saka Jong on November 9, the expedition redividing when the journey was renewed a couple of days later. On the 16th of the month the river was found to be completely frozen over. This was near Tradom, where the forces of the expedition were again united. A journey of about a week's duration through a succession of plains, full of small ponds lying among the sand-dunes, brought the expedition within sight of the watershed range, from the valleys of which issued innumerable streams to form the Tsang-po, the largest coming from a snowy range to the southwest. After they had enjoyed some days of bright sunshine the weather again took a turn for the worse, and they crossed the Mayum La on November 26 with a foot or two of snow on the ground. They had now finished with the Tsang-po, having surveyed it from Shigatse to its source.

The next point of interest was the lake district ahead. After crossing several low passes and gently



DORSAL VIEW OF THE SNAPPING TURTLE.



EGGS OF THE SNAPPING TURTLE.

the pass on the main road leading north from Lhasa, situated about ten miles from the city. From the adjacent hills (18,000 feet) he was able to sketch in carefully the adjoining valley to the north—a broad, well-cultivated, and thickly populated plain. From three points connections were obtained with the peaks of the Karo La range, while many points were fixed north and east. These included some fine snow peaks south of the Tengri Nor, the highest of which was 23,250 feet in height, this being the highest peak seen north of the Tsang-po.

Meanwhile Capt. Cowie had returned to Gyangtse, undulating ground, they came in sight of the Manasarowar Lake on the last day of the month. It was not frozen over, save for a hundred yards or so round the edge. Skirting the lake, the expedition rode across the low hills which close in on the western side, in search of the outlet which Moorcroft had not been able to find, which Strachey had found, and which Mr. Savage Landor had claimed to be non-existent. They found that Strachey was quite correct. No water was flowing along the channel from the lake at that time of the year, but the local Tibetans all agreed that for some months in each year there was a flow. As a rise

of about two feet in the level of the lake would cause water to flow down the channel, this appeared quite worthy of belief. The length of the channel between the Manasarowar Lake and the Rakas Tal, the companion lake to the west, was about three miles. This second lake was very dissimilar to the Manasarowar in shape, and was completely frozen over. The latter measured about the same from north to south (12 miles) as from east to west, and had an area of 110 square miles. The former was a long, narrow lake running north and south, some 16 miles long by 3 or 4 miles wide, with an area of some 55 square miles. It was the sacred character of the Manasarowar Lake rather than its size which had made it well known. Its height above sea-level was 14,900 feet.

An old stream bed was found issuing from the Rakas Tal, but every Tibetan of whom inquiry was made told the same story—that no water ever flowed along it now. The lakes being now entirely disconnected at all times of the year from the Sutlej River, the source of that stream must lie in the hills west of the lake region. Ram Singh was left to proceed with the survey of the Sutlej, while the main party went on to Gartok. Only one day was spent at this place, a long, broad plain, absolutely bare, with a dozen wretched hovels in the middle constituting at that time of the year what was in summer the chief trading center of western Tibet. The object of the expedition was now to get back to India as soon as possible, before the snows blocked the passes. After making their way back to the Sutlej, crossing on the way the Ayi La (18,700 feet) they found themselves in the most cut-up country they had seen; it must, Major Ryder thinks, resemble the loess formation of China, the bottom of every nullah being some hundreds of feet below the general level of the valley. Following the Sutlej Valley downward, they crossed the British frontier at the Shipki La on Christmas eve, after a march presenting many difficulties. About 40,000 square miles of country had been surveyed with the plane table, and this work had been supplemented with invaluable triangulation. At times the cold had been very severe. The minimum temperature recorded was 56 degrees of frost Fahrenheit. The lowest temperatures, however, were recorded on clear, still nights, when the cold was much more endurable than when the wind was blowing, no clothing ever invented being then sufficient to keep one warm. And unfortunately, the wind was blowing throughout most of the journey.

[Concluded from SUPPLEMENT No. 1536, page 24607.]

SUBMARINES.*

By SIR WILLIAM H. WHITE, K.C.B.

THE principles of construction for submarines were understood and applied more than a century ago by men like Bushnell and Fulton; from extant descriptions of vessels built by them, it is clear that they were thoroughly acquainted with the conditions of buoyancy, stability, and structural strength essential to the success of the type. The means at their disposal were, of course, far inferior to those which present-day workers can command, in regard to materials of construction, propelling apparatus, optical appliances, and other features. Advances made during the last few years in the design and construction of internal combustion engines, storage batteries, electric motors, and other applications of electricity, have led to great improvements in submarine construction. The earlier submarines were necessarily vessels of small dimensions, slow speed, and limited radius of action, as compared with vessels built during the last twenty years. The Nordenfelt boats of 1886-7 proved themselves capable of making long sea passages under their own steam. One purchased by Turkey in 1887 was 100 feet long, of 160 tons displacement, with 250 horse-power, and a surface speed of 11 knots, with an estimated radius of action of 900 knots at moderate speed. She made the passage to Constantinople without difficulty, and later vessels of the type proceeded to the Mediterranean and to the Baltic. In vessels of the Nordenfelt type, however, as has been mentioned previously, the use of steam power only, although efficient for surface propulsion, involved serious risks when submerged. On the other hand, when storage batteries and electric motors alone were used for propulsion, as in the "Gustave Zedé," the radius of action and speed were necessarily lower than with steam, for vessels of the same dimensions; and accidents occurred to the storage batteries, while the acid fumes proceeding from them proved dangerous to the crews unless special precautions were taken. When engines of the internal combustion type, using oil, gas, or spirit, became available, it was possible to obtain higher surface speed and a larger radius of action than with electric motors, while retaining such motors and storage batteries for propulsion when submerged. The difficulties incidental to the use of steam boilers disappear when this combination of electric motors and gas engines is made; large economies of weight and space are effected in proportion to power developed; and the weight of oil required to cover a given distance at a definite speed is much less than that necessary in the case of coal burnt in the furnaces of a steam boiler.

It is claimed that in motor launches the consumption of oil, weight for weight, is only from one-third to one-half as great as that required with coal; and that, as compared with ordinary steam launches, having equal speed and radius of action, the total weight required for propelling apparatus and fuel in the motor launch is only about one-sixth of the corresponding weight in a steam launch. Much less space is required for propelling apparatus and fuel. In submarines, with their higher powers and special conditions, the relative economy of weight and space may not be so great as in launches, but it is considerable and greatly affects the design, enlarging the radius of action and favoring higher surface speed. Precautions are, of course, necessary when gas engines are installed in comparatively small and inclosed spaces like the interiors of submarines; otherwise explosive mixtures may be formed and accidents may occur; but experience shows that with reasonable care there is no serious danger. The accident which recently occurred in "Submarine A5" has been proved to have resulted from a breach of the regulations for the management of gasoline engines in British submarines; and those regulations have been indorsed and approved by Dr. Boverton Redwood, one of the highest authorities on the subject of petroleum and its uses. Specially trained crews are absolutely necessary, not merely for efficient management of the propelling apparatus but of the vessels themselves, if the inevitable risks incidental to submarine navigation are to be minimized. The special risks connected with propelling apparatus have been and are being reduced by improvements in internal combustion engines, originating either in automobile construction or from the working of submarines; and, although improvements in secondary batteries have not yet yielded benefits such as sanguine inventors have announced repeatedly, there can be little doubt that progress will be made eventually.

Compressed air has been used as a source of power in submarines from a comparatively early period. In the "Plongeur," built at Rochefort in 1860 from the designs of Capt. Bourgois and M. Brun, this system was very fully developed, and large storage of air was carried in special reservoirs, in order to provide for propulsion, pumping, and other services. The air pressure used was about twelve atmospheres, and the renewal of supplies had to be performed at a suitable station. This vessel was in many ways remarkable, the length being nearly 140 feet and displacement about 450 tons. Full particulars were published by Admiral Paris in L'Art Naval, and many features of the design have been influential on subsequent practice, although the "Plongeur" was not a successful vessel.

In modern submarines the use of locomotive torpedoes practically necessitates the employment of compressed air, and its use is naturally extended to other services, especially to the ejection of water from the ballast chambers. Great improvements have been made by mechanical engineers in air-compressing machinery; and, with internal combustion engines for surface propulsion, it is possible to make submarines self-contained in regard to the renewal of supply of air under pressure. Similarly the charging of storage batteries can be independently performed, and the power of independent action over greater distances can be secured, with consequent enlargement of the services of which the type is capable.

As to the possibility of the crew remaining submerged for long periods if required, no difficulty remains; thanks to the arrangements made by chemists for purification of the air in the interior spaces. Repeated proofs have been given of this power, and in service there is likely to be no necessity for very long submergence; although, when "awash" at sea, no doubt, it will frequently be necessary to shut down most or all of the openings to the outer air.

With steel of modern qualities as the material for hull-construction no difficulty is felt in producing submarines of any desired form or dimensions, with ample strength to sustain the maximum external pressures likely to occur on service. A large margin of strength is necessary, however, as experience proves that submarines may and do reach, by accident, greater depths than were intended, and in some instances they have touched the bottom.

On the whole, therefore, designers of submarines in the present day have at their service greater facilities than their predecessors enjoyed; and have thus been enabled to meet demands for higher speeds and larger dimensions. But it is equally true that their work displays no superior knowledge of principles, nor any great novelty in provisions made for safety and maneuvering power.

Various methods have been suggested and employed for enabling submarines to dive. All of them require that before submergence takes place a vessel shall be brought, by the admission of water into tanks or chambers, into a state which leaves a very small "reserve of buoyancy"; nearly the whole volume of the vessel being immersed and all apertures being hermetically sealed. The "reserve of buoyancy" must be small, otherwise it is not possible to effect submergence and to maintain a fairly constant depth below the surface. In the largest vessel of the Nordenfelt type, for instance, when ready for diving the reserve of buoyancy was only 300 pounds, as against a total weight of 230 tons for the vessel and her contents, including nearly 50 tons of water-ballast; that is to say, the admission of 30 gallons of water would have destroyed her buoyancy and sent her to the bottom, unless water-ballast was expelled, or other means were taken to reduce the total weight and create a reserve of buoyancy. The Holland submarines, like those first adopted for the royal navy, have a displacement when "awash" of 105 tons, and when submerged of 120 tons; the reserve of buoyancy being about 300 pounds. Capt. Bacon, R.N., has stated that this question of the reserve of buoyancy is one of the most important in connection with submarine design; and for a vessel of 500 tons he fixed the maximum reserve at one ton, or only two-tenths of one per cent of the displacement. Thirty-five cubic feet of sea-water weigh one ton, and a small crevice would admit that quantity in a very short time, if the vessel were at a moderate depth below the surface. Further, Capt. Bacon remarked very properly that as a submarine may have to change from water of one density to another, during her service, this very small reserve may become a critical matter. For example, take the case of a submarine which in the diving condition weighs 120 tons, and has a reserve of buoyancy of 300 pounds, when floating in sea water. She might run a few miles up a river and reach water weighing only 63 pounds per cubic foot—or one sixty-fourth less than sea water. In order that she should not sink below the draught at which she floated in sea water, about two tons of water must be expelled from the ballast tanks.

This is not the place to enter further into technical details; enough has been said to indicate how narrow is the margin of buoyancy that has to be accepted, how small a deformation of the vessel or inrush of water may destroy it, and how thorough must be the precautions taken both in design and in working in order that submarines may be brought promptly and yet with certainty into the condition for diving from the ordinary or "awash" condition. This nicety of adjustment and balance, moreover, must be maintained while the vessel is in the diving condition; as weights are expended or received, compensation must be provided, so as to secure constancy in total weight and in the "trim" of the vessel.

Devices for the rapid restoration of buoyancy to submarines in case of accident form essential features of the designs. The expulsion of water from the ballast-tanks by means of compressed air or pumps is one common method. The use of detachable weights is a favorite plan for effecting the same result. Still another method that has been tried consists in having the means of increasing the external volume of the vessel by thrusting out pistons through orifices in the skin fitted with watertight joints. Theoretically all these methods are sound; in practice their value and efficiency depend upon the time available for the crew to make use of the means provided. Serious damage to the skin of a submarine permitting the rapid inflow of large quantities of water may and probably will deprive the crew of opportunity for utilizing any means of safety. It has been recommended to divide the interior space into separate compartments by watertight bulkheads in order to increase safety. This system has proved of great value, and is now largely adopted for ordinary ships. Officers of great experience in submarines, however, do not favor similar subdivision. Capt. Bacon put the case strongly when he said:

"There are many other considerations to be taken into account. I do not know whether the fact has ever struck any of you that one of the main considerations in the design of a submarine is a knowledge of the physical conditions of the men. . . . One thing that comes out more than another is that you cannot put a man into a compartment that is too small. . . . There is an impossibility of getting men to work under normal conditions (in abnormally confined spaces), and a man not working under normal conditions is sure to be flurried and useless."

Obviously increased risks must be run if advantage is to be taken of increased offensive power resulting from the capability of a submarine to dive and deliver an underwater attack; and it is necessary to have regard to both sides of the subject when the value of submarines is appraised. It is not possible to secure the power of diving rapidly without accepting the risk of going to the bottom before the enemy is reached. Formerly when spar-torpedoes only were employed, submarines ran the further risk of inflicting fatal injuries on themselves in the process of injuring or destroying an enemy. The history of the Confederate "David" at Charleston during the American civil war proves that men will never be wanting who will face all risks in the hope of sinking a much larger and more powerful ship. Although subsequent improvements in the construction of submarines and the use of locomotive torpedoes have made the risks to be run less serious than those faced by successive crews of the "David," it still remains true that the officers and men serving in submarines must be devoted and courageous as well as skilled.

When a vessel of the submarine type is floating at rest she is, of course, subject to the universal law applicable to all floating bodies; the weight of water which she displaces (that is, the weight of water which would fill the cavity occupied by the vessel) must equal the total weight of the submarine and all that she contains. When the water-ballast chambers are empty the vessel weighs less, displaces less water, and has a greater freeboard and a larger "reserve buoyancy." The reserve of buoyancy is measured by the external volume of the water-excluding portion of the vessel lying above the surface of the sea. After the water-ballast tanks have been filled in order to prepare for diving, the weight is proportionately increased, the vessel sinks deeper, the cavity she occupies (that is, her "displacement") becomes greater, and the reserve of buoyancy (as explained previously) becomes very small. If a further quantity of water was very slowly admitted and the reserve of buoyancy could be exactly balanced, the submarine would float, either with the uppermost portion coincident with the surface of the water, or in any position within a reasonable depth below the surface, but in practice such an exact balance cannot be secured easily. In popular writings on this subject there is sometimes confusion between the fluid pressure due to the head of water—measured by depth below the surface and increasing with the depth

* From the Engineering Supplement of the London Times.

—and the buoyancy (or floating power) of a submerged vessel—measured by the weight of water displaced. That weight is equal to the volume of the displacement multiplied by the weight of the water per unit of volume. For practical purposes, and within the limit of depths occurring in practice, water may be regarded as incompressible; so that the weight per cubic foot remains practically the same at all depths. Fluid pressure, on the other hand, increases with the depth, and designers must insure an ample margin of structural strength to resist the pressures sustained at the *maximum* depths to which submarines may descend and to prevent deformation of the structures. If the structures yield sensibly under external pressure, the volume of displacement will be diminished, and the weight of water displaced will be reduced; there will no longer be a balance between the weight of the vessel and the buoyancy, and she will sink to the bottom unless immediate steps are taken to diminish weight by expelling water from ballast chambers or by releasing detachable weights. Assuming that sufficient structural strength has been provided to insure rigidity of form, it is possible to submerge a vessel, which has been brought into the condition for diving, by intentionally diminishing the displacement. This method was adopted in many early submarines, and has been used in some vessels of later date. For example, the "Nautilus," which was tried in this country in 1886-7, was fitted with a number of plungers passing through watertight orifices in the skin, and capable of being protruded or withdrawn by means of screw gear operated by manual power in the interior. When the vessel was ready for diving, these plungers were extended to their full projection, and their volume formed part of the total displacement. In order to dive, the plungers were drawn inward, the volume of displacement was diminished, the weight of the vessel then slightly exceeded the buoyancy, and she began to sink. It was intended that, as soon as the desired depth was reached or approached, the plungers should be again thrust out, and equality of weight and buoyancy restored, so that the vessel should maintain that vertical position while she moved ahead. As a matter of fact the protrusion of the plungers could not always be effected with sufficient rapidity, or with the nice adjustment necessary to prevent the vessel from going beyond the depth that was desired. In a trial when I was on board this difficulty proved insurmountable; the vessel reached bottom in the deep-water dock at Tilbury and remained there for a considerable period in spite of all efforts to bring her to the surface. On consideration it will be seen that a submarine floating at rest at any depth below the surface must be in a condition of unstable equilibrium, so far as vertical movement is concerned. Theoretically the slightest excess of weight over buoyancy must cause deeper immersion; while an excess of buoyancy over weight must bring a submarine to the surface. When submergence is taking place, considerable velocity may be acquired in the downward motion; and, even when the original displacement is restored or an excess of buoyancy is secured, the vessel is liable to be carried beyond the depth intended. In other words, oscillatory movements would be likely to take place about the desired depth, and there always must be danger of going to the bottom when this system of submergence is adopted, while the maintenance of a constant depth below the surface is a practical impossibility unless other means of control are provided.

In order to overcome this difficulty, Bushnell's boat, the French "Plongeur," and the Nordenfelt boats had small screw propellers carried on vertical shafts; and by their operation the small reserve of buoyancy left when the vessels were in the diving condition was overpowered when diving, while the maintenance of any desired depth was made possible. Experience with submarines has, however, led to the universal use of horizontal rudders controlled by operators within the vessel for the purpose of effecting submergence. When such rudders are employed and onward motion is given to the vessel by placing the rudder in appropriate position, the bow can be depressed, and the vessel can be made to dive until the desired depth is reached. By subsequent manipulation of the rudders it is said that this depth can be maintained with practical constancy. The principle is identical with that adopted in locomotive torpedoes where the rudders are automatically governed by means of a balance-chamber fitted with controlling apparatus, so set as to keep the torpedoes at any desired depth below the surface; the action of that apparatus being dependent on the law that fluid pressure varies with the depth. It has often been proposed to fit similar automatic arrangements for controlling the vertical position and movement of submarines; but the highest authorities seem to agree that better results can be realized when rudders are worked by skilled operators, who keep careful watch on the indications of gages showing the depth below the surface and the maintenance or otherwise of a horizontal course. Within the limits of speed which have been attained below water there appears to be no difficulty in reaching and maintaining any desired depth; and preference is naturally given to personal control, since experience proves that the best automatic appliances occasionally go wrong, and, therefore, cannot be trusted absolutely. Locomotive torpedoes not infrequently behave erratically, and sometimes disappear altogether. In these weapons there is a necessity for automatic appliances, but in submarines that necessity does not exist, and the much larger dimensions impose greater difficulties, while the presence of crews involves more serious risks. A submarine controlled by horizontal rudders can only remain submerged so long as she is in motion. When onward motion ceases the controlling power of the rudders disappears, the reserve of buoyancy is free to act, and the vessel rises to the surface.

The question of the *maximum* speed which can safely be given to submarines when navigating under water is closely associated with the maintenance of a constant depth. Increase in speed necessarily involves large additional power and much greater weight of storage batteries, if electrical propulsion is adopted; but this requirement can be met by increased dimensions and cost. Higher under-water speeds also require a reconsideration of the forms of submarines, and particularly the forms of superstructures which are situated above water when the vessel is at the surface. Capt. Bacon has drawn attention to the conflicting claims of the forms best suited for the attainment of good speed at the surface and those which would be adopted if under-water propulsion only, or chiefly, had to be considered. Every one who has looked into the question will concur with him that the problem is a difficult one, although many proposals for much higher speeds at the surface and under water have been made by those who were imperfectly informed or had not fully realized the difficulties to be overcome. Of the two claims that for higher surface speed seems superior, since the danger of capture or destruction of submarines by swifter vessels would thus be sensibly reduced.

Taking all circumstances into account the advantages resulting from any large increase in under-water speed would probably not compensate for the much greater risks accompanying such increase of speed, even when skilled operators are in charge of mechanisms controlling horizontal rudders. For example, an under-water speed of ten knots corresponds to an advance of about 17 feet per second. If a vessel "trimmed" by the bow only ten degrees from the horizontal, in each second of time the depth below water would increase by about 3 feet; so that this comparatively small departure of course from the horizontal would involve an increase of 180 feet in depth below the surface in one minute even at this moderate speed; and at fifteen knots only forty seconds would produce an equal increase in depth, with the same departure from the horizontal. Furthermore, it must be noted that when a submarine is in motion the water-pressure on the rudder is governed by its area, by the angle of helm, and by the *square* of the velocity; so that, other things remaining unaltered, a change in under-water speed from eight to ten knots would increase the rudder effect by 50 per cent and would demand correspondingly increased rapidity and delicacy of manipulation of the rudders in order that constancy of depth should be maintained. Since the longitudinal stability of a submerged vessel is very moderate in amount (being identical with that for transverse inclinations) it is obvious that the liability to disturbance of "trim" must always be considerable; and with the large proportionate increase in rudder power accompanying higher speeds this liability would be much increased. In addition, for a submarine diving at high speed, there would necessarily be a danger of the pressure on the forward part of the vessel still further increasing the "dip" of the bow, and so tending to carry the vessel to depths which might involve serious risks from increased external pressure or from striking the ground. Nor can it be overlooked that even with the best optical arrangements the control of the movements of a submerged vessel at the moderate speeds hitherto reached is not an easy matter, while the operations would be made much more difficult at higher speeds. So far as my observation and experience go, the strongest advocacy of higher speeds for submarines comes from persons whose experience in actual work with vessels of the type is very limited. Those who have had large experience are more cautious and do not commit themselves to extreme opinions. It may well happen that, as experience is enlarged, speeds may be increased in successive types of submarines, but the advance will probably be gradual and its limits will be determined by considerations of size, cost, manageability, and offensive power. In his speech on the navy estimates, Mr. Pretyman stated that the B class of British submarines have a surface speed of 13 knots and a radius of action of 500 miles; while the under-water speed is nine knots and radius 90 miles. These vessels are said to take three minutes to dive.

There is now universal recognition of the necessity for some form of optical instrument which can be projected above water in order to furnish to the navigating officer of a submerged vessel the means of ascertaining the position of an enemy. Many forms of these instruments have been devised and further improvements will, no doubt, be introduced giving enlarged fields of vision or more perfect representations of objects above water. On the other hand, no perfection of optical instrument can overcome some difficulties that have to be faced in practice; the most serious of these arising from the fact that, at the moderate height above water at which the lenses must be carried, there is a great danger of vision being obscured by spray and water thrown upon them. It is a matter of common experience in torpedo boats and other small, swift vessels that this difficulty is encountered in looking through the glass of conning-towers or steering positions; and it is necessary to remove water frequently from the surface of the glass in order to get a clearer outlook; the difficulty must be greater in the case of submarines. There is every reason to believe that the "periscopes" used in British submarines are at least of equal efficiency with corresponding instruments supplied to foreign vessels of this type. Naturally, but little information has been published on this subject, which is one of those where the confidential treatment of experience is desirable. From reports published in the United States on trials with submarines there is, however, ample confirmation of the opinion expressed above as to the limited usefulness of "periscopes." It has been stated, for instance, that while the relative positions of objects can be determined with such instruments, there is great difficulty in judging distances accurately, and cases have been known where submarines have struck the walls of docks in which they have been tried, although these appeared to be distant. Under these circumstances it is a matter of great importance that submarines should be capable of diving rapidly when required so that they can rise to the surface when making an attack, determine their position and further course, and then quickly disappear. In the Holland boats, tried in the United States, of types similar to those first constructed for the royal navy, the time occupied in making ready for submergence, starting from the light condition, was from twenty-five to thirty minutes. This time was occupied in stopping and disconnecting the gasoline engine, removing ventilators, closing openings and admitting water ballast, and connecting the electric motor; with certain modifications the time could be reduced. The reserve of buoyancy when ready for diving was only about 300 pounds—or one nine-hundredth part of the total weight. At the surface the speed was eight to nine knots, under water about seven knots. On one of the trials at this moderate speed the vessel struck the bottom and remained there for some time, not rising until the water-ballast was expelled. Considerable interest attaches to these authentic statements of performance, which confirm the necessity for careful management by thoroughly trained crews. In the royal navy only one submarine, the unfortunate A1, has been sunk by accident, and that by collision with a passing steamer, since trials began. This fact has a two-fold significance. It indicates that our naval authorities have taken proper precautions in the experimental working of these novel vessels and the training of crews; and it demonstrates also that, whatever may be their value in naval warfare, submarines are, and always will remain, weapons which require delicate handling by officers and men.

EVOLUTION OF HEAT WHEN POWDERS ARE WETTED.

SINCE Pouillet first demonstrated in 1822 that finely-powdered substances like glass and sand become heated on being wetted with water, many experiments have been made and many theories suggested in explanation of this Pouillet effect. Pouillet himself referred it to capillary attraction; Tate to chemical combination, which is generally considered to be out of question; Cantoni—and later, Nelsens—suggested that water passed into a different state of aggregation when wetting powders, either into the solid state or some intermediate state between the solid and liquid.

This explanation was taken up by Martini a few years ago, who communicated the results of his researches to the Academy of Science of Venice. Martini believes that water solidifies when settling on powders. Bellati and Finazzi objected that in that case the specific heat of the absorbed water should be diminished, which they did not find to be the case. From very careful experiments on silica in different states of dryness, these latter observers concluded that almost dry silica liberated 18.5 calories per gramme of silica on being wetted, and that this evolution of heat decreased as the moisture increased. For perfectly dry silica they deduced, by extrapolation, the value 26 calories. But their formulæ were not simple, and their statement that the size of the grains had no influence contradicted Gore and Linebarger and other experimenters.

Renewing his investigations last year, Martini adheres to his opinion. A very important contribution to the problem was, in 1902, presented to the Physical Society of London by G. J. Parks, who concluded that when silica, sand, and glass are brought in contact with water, the heat evolved is proportional to the exposed area of the solid, and that about 0.00105 calorie is evolved per square centimeter when the temperature is near 7 deg. C. It is presumed that the substance is quite dry, that there is no chemical action, and that the substance and the water are at the same temperature.

In a paper published in January in the Annalen der Physik, vol. xvi. page 32, G. Schwalbe draws attention to a crucial point which has not been considered by most experimenters. Schwalbe's father had taught that the formation of ice within fissures and caves, whose mean temperature was not below the freezing point, was due to the fact that water of less than 4 deg. C. became cooled, instead of heated, in percolating through the sandy walls of the cave. This view was experimentally supported by Jungk, and contradicted by Meissner, but is now shown to be correct by G. Schwalbe, whose experiments, conducted in Berlin, on the whole agree with those of Parks. Schwalbe demonstrates that in general, dry sand (silica, glass) becomes heated when in contact with water; but when the temperature of the water is below 4 deg. C. it becomes cooled, and when just at 4 deg. there is neither cooling nor heating. This would be in concordance with Lord Kelvin's formula for the temperature change due to the compression of a liquid which results when a surface film forms. Both the density and the expansion coefficient of water enter into the formula, and as these quantities change their signs for water at 4 deg. C., there should be a reversal in the Pouillet effect, such as Schwalbe

has now established. The point is of considerable interest, not only to physicists, but also to geologists and engineers.—Engineering.

THE MOUNTAINS OF THE MOON.

By R. S. TOZER.

THE accepted theory of volcanic origin, in my opinion, fails to account for the peculiar features of the lunar mountains. A theory has been proposed which accounts for all these peculiar features, but it has found no favor with astronomers, and is not even mentioned in the leading works on astronomy.

Briefly stated, the theory is this: At one time the moon's surface was plastic for a depth of perhaps a mile. During this period there fell on the lunar surface a vast number of small globes ranging in size from about twenty miles to a few feet in diameter, and varying in structure from liquid to solid.

The surface of the moon is indented with an almost countless number of basins, circular in form, and of all sizes up to one hundred and forty miles in diameter. In fact, several ranges of mountains are disposed in such a manner as to form the broken rim of a basin at least five hundred miles in diameter. There seems to be an entire absence of such mountain ranges as form the backbones of terrestrial continents.

The basins are called craters. Some of them bear a good resemblance to terrestrial craters, but the greater part do not, nor can their peculiarities of construction be explained by means of any volcanic theory, while the theory of falling bodies explains them all. The great size and number of these so-called craters are especially worthy of remark. All of the craters of the earth might be contained in one of these lunar basins with room to spare. Does it not seem that such a comparatively small globe as the moon would not need such an enormous safety valve area as, according to the volcanic theory, is represented by the lunar basins?

If, as has been said, the moon is a burned-out earth, its surface should bear a fair resemblance to that of the earth. But if the earth were divested of its aqueous covering, its surface would appear to a distant observer to be far different from that of the moon.

One type of lunar basin is marked by a rim having two crests with a circular trough lying between.

The great crater Clavius is an example. In this case the trough or ravine is somewhat broken, but can be easily traced. There are numerous other smaller basins with the circular trough. This peculiarity, which the volcanic theory fails to account for, is very easily understood when the basin is considered as being an indentation. Several basins of this type will be noticed in the photograph that accompanies this paper. The subject was made by spreading on a firm wooden backing a layer of plastic clay, and throwing against it a variety of balls of the same material. The basins with the circular ravines were made by using as projectiles balls of stiff plastic clay. The inner crest of the basin's rim is the edge of the flattened projectile. The lunar basins with the central peak look somewhat like volcanic craters, and Prof. Brashear has, by a miniature volcanic process, made a very good imitation of these, but the same effect has been produced in the photograph by using as a missile a ball of the clay that had been partly dried. But the most striking feature to be seen on the moon's surface is the great crater Tycho with his radiating streaks. These streaks are several miles wide. Some of them are a thousand miles long, and they are all straight. No explanation worthy of the name has ever been given. I quite from Young's "General Astronomy," page 178:

"Most curious of all are the light-colored streaks or rays, which radiate from certain of the craters, extending in some cases a distance of several hundred miles. They are usually from five to ten miles in width, and neither elevated nor depressed to any extent with reference to the general surface. They pass across mountain and valley, and sometimes through craters, without any changes in width or color. We do not know whether they are like the so-called trap dikes on the earth—fissures that have been filled up from below with some light-colored material—or whether they are mere surface markings. No satisfactory explanation has ever been given."

I quote further from Newcomb's "Popular Astronomy:

"Among the most curious and inexplicable features of the moon's surface are the long narrow streaks of white material which radiate from certain points, especially from the great crater Tycho. Some of these can be traced more than a thousand miles. The only way in which their formation has been accounted for is by supposing that in some former age immense fissures were formed in the lunar surface, which were subsequently filled with the white matter which forms the streaks."

A very little study of Tycho and the surrounding territory is sufficient to show the absurdity of this explanation. Even if such a system of straight fissures hundreds of miles long could be opened on the lunar surface by natural means, which is impossible, an eruption of light-colored matter would, wherever the side of the crevasse was low, overflow, filling up such craters and valleys as were in its path, making the streak ragged and irregular. Furthermore, the lowest visible stratum on the moon is dark, the configuration of the edges of the light-colored portion showing plainly that the darker portions extend underneath. Whence, then, the light-colored lava?

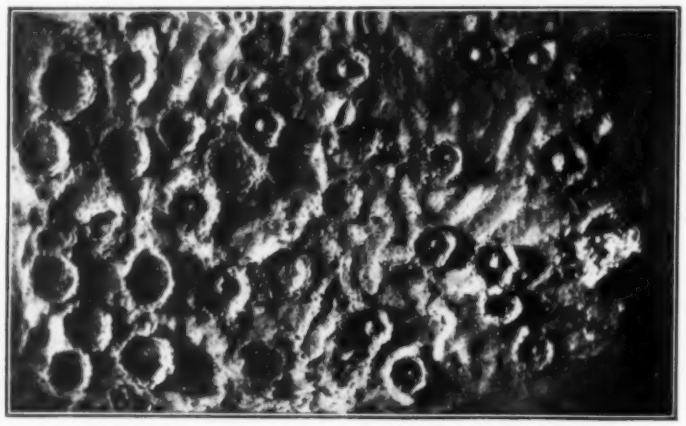
Were the fissures formed and filled up by volcanic action, the contour of the surface would be so changed that the streaks could be traced when the sun is rising on that portion of the lunar surface. But they are invisible at that time, and are most brilliant when the sun is on their meridian, showing that they are color streaks only.

There is only one way in which such a feature as Tycho and his radiating streaks could have been formed. If any friable body with much free liquid in its composition be projected with sufficient force against a firm surface, a spot similar to Tycho will be the result. A practical illustration of this can be had by throwing a ripe apple smartly against a smooth wall. An attempt was made to produce a Tycho on the clay model by using as a missile an eggshell filled with white paint. The spot produced was not considered sufficiently successful to be used as an illustration, but the tendency of colliding bodies to throw their fragments in all directions from the point of collision is well known, and really needs no experiment to demonstrate it.

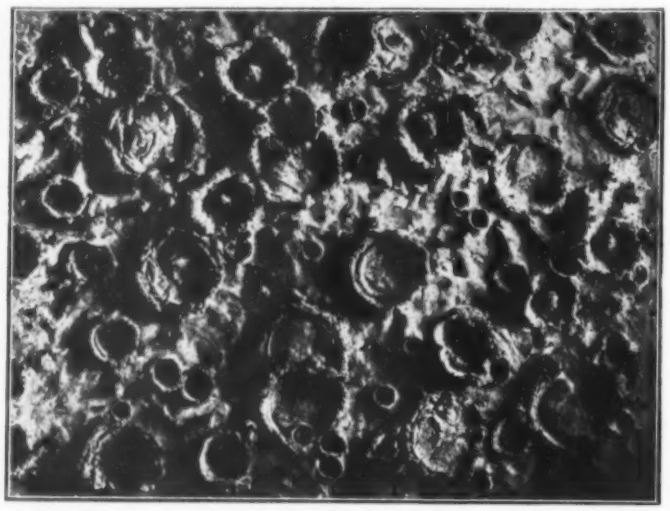
Tycho was probably caused by the impact of a liquid globe about ten miles in diameter, and traveling at a comparatively low rate of speed.

When a stiff plastic sphere strikes a plastic surface, the mushrooming process is arrested before the projectile can spread to the size of the indentation. When a softer plastic sphere strikes, the spreading process is not stopped until the flattened projectile extends over the edges of the indentation; and when the liquid sphere which produced Tycho struck, it spread with such force as to shoot far out over the rim of the basin it scooped out, leaving the wonderful streaks to mark the paths of its different portions.

Several objections have been advanced against the theory. The three most plausible will be considered in this paper.



ARTIFICIAL LUNAR MOUNTAINS PRODUCED BY HURLING BALLS AGAINST PLASTIC CLAY.



ARTIFICIAL CRATER RESEMBLING THOSE OF THE MOON PRODUCED BY HURLING SMALL GLOBES AT PLASTIC CLAY.

First: There are no terraces on the slopes of the craters in the photograph, while there are many on the craters of the moon.

It should be borne in mind that the experimental craters are on a much smaller scale, and it is difficult, if not impossible, to reproduce all the details of the lunar craters. But if such a basin be formed by the impact of a small globe on a layer of rather stiff plastic material, with a considerable degree of cohesiveness between its component particles, the sharp upward curving of the layer will produce wrinkles similar to those produced by bending a piece of heavy leather. The clay used in experimenting possesses a moderate degree of cohesiveness when it is mixed rather soft, but the property decreases rapidly as it hardens, so that instead of wrinkling on the upper surface, it will crack underneath.

Second: But these globes must have been coming at planetary speed, consequently they would produce a much greater effect, and in many cases they would strike glancing blows, whereas the force producing the lunar basins has always acted in lines perpendicular to the surface.

If some geologist should find in the Devonian stratum the fossil remains of a grizzly bear, no amount of theorizing would prove that the bear was of later origin than that stratum, and present theories as to the succession of animal forms would have to be reconstructed. By the same line of reasoning, if the so-called lunar craters are shown to be the marks of projectiles, theoretical reasoning as to the non-existence of suitable conditions will be of no avail. (It is necessary, of course, to assume that the globes were drawn to the moon by its gravity.) We have no knowledge of the conditions that existed at the time of the formation of these basins. All is pure theory.

If it is assumed that a world is formed by the assembling of smaller bodies, no valid reason can be urged against the probable existence of just such conditions as are needed for the theory.

Third: If the impact theory be true, why is it that in cases where one basin overlaps another, the larger one has always been formed first? In other words, does it seem reasonable that the globes should have fallen in the exact order of their size?

The chances of a larger basin being formed partly covering a smaller one, and not completely obliterating it, are rather few. However, there is at least one case of this kind. Just outside of the crater Longomontanus is a part of an older one, its rim forming, with part of that of its neighbor, a well-marked crescent. The old crater in this case is about two-thirds the size of the later one.

A careful study of the roughest portion of the moon's surface reveals a number of basins made at an early period when the plastic layer was soft and more easily affected by gravity. These basins are simply depressions, the crest of the rim having flowed down to the level of the surrounding plain. Their details are not so distinct as in the more recent ones.

I quote from Young's "General Astronomy," page 176:

"It is noticeable that as on the earth the newest mountains are generally the highest, so on the moon the newly-formed craters are generally deeper and more precipitous than the older ones."

These older basins are of all sizes, many of them being much smaller than the newer ones, which fact effectually disposes of the theory that they have all been formed in the exact order of their size.

The projectile process is the only one (outside of modeling) by which a good imitation of the different types of lunar basins can be produced. The origin of Tycho and similar basins, with other striking peculiarities, can be explained only by the theory of falling bodies, and it would seem that unless some more serious objection can be urged, it should displace the volcanic theory.

[EDITOR'S NOTE: Interesting as the theory advanced in the foregoing article undoubtedly is, it is objectionable in respects that have been enumerated from time to time by prominent astronomers. If the moon's volcanoes were formed by bodies impinging against it with planetary velocity, and the volcano walls were produced by the radial thrust of these bodies, how is it that in the bottoms of the craters no trace of them can be detected? A body colliding with the moon at a speed of thousands of miles per second must have had sufficient energy to pierce the thin lunar crust, and to permit the escape of volumes of lava quite sufficient to fill the opening made. Instead of lava-filled punctures, however, we find simply great pits with well-defined floors. The radiating fractures or crevices that impact would have produced are singularly absent, both in large and small volcanoes. No evidence can be found of more lava having issued from the larger than from the smaller craters—a result that might reasonably be expected to follow from the author's theory. Moreover, the thickness of the walls of the large volcanoes is often no greater than that of the small volcanoes, which is just the reverse of what would happen if the craters were produced by the impact of bodies against the moon. The lunar arrangement of many of the volcanoes, an arrangement that presupposes an internal force acting in well-defined directions, cannot possibly be explained by the theory advanced. Bodies are not apt to move with military precision in a solid phalanx. There is no evidence that the earth has ever been struck by any body sufficiently large to have formed a crater. If the moon has been thus bombarded, how comes it that a body like the earth of enormously greater attractive force bears no marks of any collision with a projectile? If Newton's law holds good, more bodies should have struck the earth than the moon. If a body only a few miles in diameter had impinged against the earth, assuming it to have been moving at planetary velocity, it would have developed so enormous an amount of heat, that organic life would have been entirely destroyed. And yet, life has existed on this earth without interruption from very early geological periods.]

QUICK PROCESSES IN MODERN GEODESY.

THE series of studies presented in a preceding article foreshadow a great simplification in the measurement of geodetic bases. In fact, the discarding of rigid rules and the substitution therefor of long wires that are capable of being wound up after their determination, and unwound only upon the ground of the base, and that serve for fixing the position of a series of aligned bench-marks, is destined to permit of proceeding by long stretches with a light material manipulated by a limited number of persons.

It remains for me now to make known the processes that permit of deriving the greatest advantage possible from the use of wires and to show the precision that they guarantee in the field.

The experiments made by M. Benoit and myself at the International Bureau and which followed as far as possible, at the outset, the information given by M. Jäderin, soon showed us that it was possible to modify, with some advantage, the material devised by him. The tension by dynamometers that he recommended presented some rather serious difficulties, and this is the first thing that we had to contend with. If we remark that a wire passing over a pulley and having its two halves respectively vertical and horizontal, exerts upon the pulley a pull at an angle of 50 degrees with the horizon, we shall conclude that, if the wire is stretched by a weight, it will suffice to carry the guide pulley upon a rod having the above inclination in order that the wire may be held in place without any effort, that is to say, under the best conditions of stability (Fig. 1), while giving us, moreover, the liberty (which we do not have in the use of the dynamometer) of making the wire slide in the direction of its length, and of making as many independent readings as may be deemed necessary. The assistant who carries the rod can rest it against his shoulder, and all that will be required of him will be to remain as immovable as possible for an instant while keeping the wire in alignment with the bench-marks. If still greater stability be required, a tripod may be formed (Fig. 3) by the addition of two other rods connected by a crosspiece on top, the crosspiece being pivoted and carrying the first rod, which receives the entire pressure from the weight in the form of a compression strain.

For movable bench-marks, of which the wire serves for determining the distance two by two, we adopted some new principles. The models were afterward made with the co-operation of M. Carpentier, who is now constructing the apparatus represented in Fig. 2. A small platform forming the top of a vertical socket, *D*, is capable of being readily turned on top of a wooden tripod. This platform having been put in place, a nut, *E*, threaded upon the socket is screwed up, so that the platform is held firmly in place in the position it is set on the tripod. Upon the platform is placed a small metal tripod held in place by three springs bearing against the points of the leveling screws, and upon which rests a table surmounted by a vertical stud, *G*, the micrometric displacement of which may be changed by means of three horizontal screws, whose nuts project at the circumference of the tripod. The stud is provided with a vertical aperture into which passes a lead wire that permits of marking the point on the ground situated vertically beneath the point of attachment. This latter is surmounted by cross-lines formed at the upper part of the stud. A conical side piece serves alternately as a support for a reference point and for a telescope provided with a level and designed, through the sighting of the reference point carried by the neighboring tripod, for measuring the difference in height of the successive tripods for the purpose of reducing to the horizontal the distances apart of the bench-marks directly determined by means of the wire.

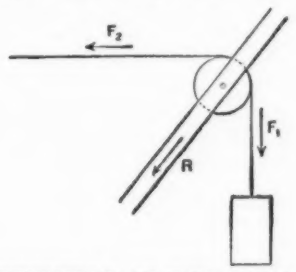


FIG. 1.—PRINCIPLE OF THE TENSION BY A WEIGHT.

R, resultant of the forces F_1 and F_2.

The measurement of a base by means of this apparatus requires two groups of operators. A tripod having been put in place in the perpendicular of the starting point of the base, a gang of three men (a chief and two assistants) starts forward and puts in place another tripod, which it aligns upon a distant sighting point, and the distance of which it fixes at about two or three centimeters by means of a cable gage. A third tripod is placed in the same way, and

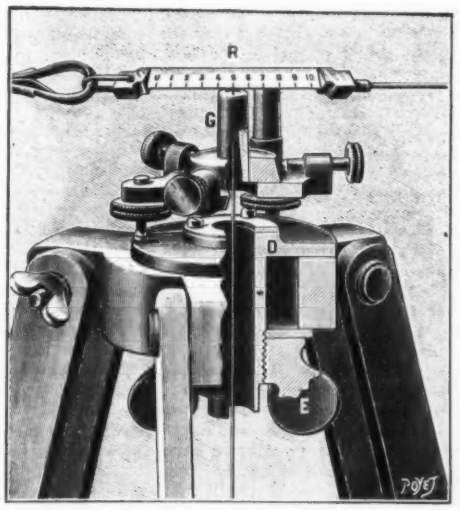


FIG. 2.—TOP OF THE LEVELING TRIPOD.

then a fourth and so on. After the first stretches are cleared, a second gang begins its work. The observers put the wire in place and fix it to the hooks terminating the tension cords. The assistants free the weights and finish the alignment of the pulley supports, and the measurements are then begun (Fig. 3). The principal observer in the first place measures the inclination of the wire, and the two observers rest the rules, *R*, lightly on top of the reference marks (Fig. 2) simultaneously read at the two extremities the position of the latter with respect to the scales, move the wire a short distance lengthwise and repeat the readings, so as to obtain a group of five or six. The observers afterward take the wire in hand, the assistants hook the weights to the rods, and the gang starts for the following stretch. After this has been measured, and the position of the three bench-marks at least has been fixed, a carrier takes up the first tripod and carries it to the first gang. The measurement is continued thus through the simultaneous work of the two gangs, each stage increasing, by 24 meters, the length measured.

When a sufficient number of tripods is available, the work is done without any drawbacks, the slight retardations of one or another gang being compensated for upon other stretches, and the rear gang always finding the stretches prepared and the field clear for the measurements. With an experienced force, working on good ground, the progress made is from 25 to 35 stretches an hour. A base of 10 kilometers (6 miles) ought therefore to be easily measured in four hours in the going and returning. The force consists of half a score of men, three for the first gang and five for the second, inclusive of a secretary and one or two carriers for transporting the tripods.

The precision of these measurements is very great. In fact the accidental error that may be made in the determination of an interval, provided the observers be experienced, never exceeds 0.1 of a millimeter. This error increases from one stretch to another through the law of addition of fortuitous errors, that is to say, that after n^2 measurements, the total error is equal solely to n times the probable error of a single measurement. At the line of a hundred reaches, the possible error due to the readings alone will therefore not amount to 1 millimeter, say 1/2,400,000 in relative value. This is not saying that the base is really known with an accuracy of such order. The error of the value of the wire, that of the inclination, and the displacements of the tripods between two bench-marks are so many causes that may sensibly increase this calculated error; but it nevertheless remains indubitable that the method of reading the wires, as elementary as it may be, answers all the requirements of geodesy.

The precision that the invar wires are capable of affording is due, it must not be forgotten, to the fact that errors of temperature do not intervene, while they are absolutely predominant in the use of an ordinary metal or alloy. So, the Jäderin method, which was to have remained limited to reconnaissances, to rapid surveys, and, in general, to topographical operations, has been able to cross the boundary line that separates this science from geodesy, and is now applicable to the most precise determinations.

There results from this, for geodetic measurements in general, an entire transformation upon which it is proper to dwell. As the personnel is reduced to about a fifth of what it was formerly, and since the quickness of operation is increased tenfold, the cost of the measurement of a base of the same length is reduced to about two per cent. Hereafter we shall therefore be able to determine a large number of bases without undue expense and lay out the system of triangles with the aid of numerous controls. The measurement of the angles will itself become easier, since we shall no longer have to fear the agglomeration of the errors along the entire system.

The old processes of measuring bases were doubtless capable of affording a little greater precision for each reach; but the different junctions of the reaches with each other added sensible errors to the whole. Since the measurement of the first angle causes a loss of a goodly portion of the accuracy assured by a measurement with the rule and microscopes, we ought to consider such extreme precision as superfluous, and we should prefer to it a less degree of initial accuracy, compensated for by a close control of the entire system of triangles.

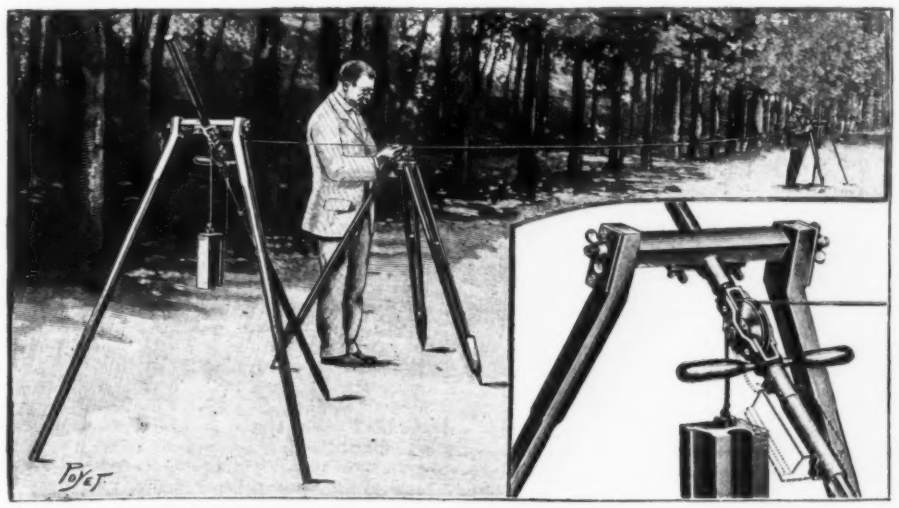


FIG. 3.—MEASUREMENT OF A BASE BY MEANS OF A WIRE.

The apparatus shown stretches the wire by means of weights. The position of the weight when the apparatus is being transported is indicated by dotted lines.

The use of invar wires no longer remains an affair of the laboratory. They have been put to the test in the field in recent years in several important measurements. Thus, for example, the expedition sent out by the Russian and Swedish governments to determine the value of an arc of meridian of 5 degrees embraced

by the Archipelago of Spitzbergen measured all its bases with invar wires, and obtained an extremely satisfactory concordance between the various operations undertaken. During this expedition, M. Jäderin had the kindness to give me an account of the measurements in which he took part, and the preparations for which I had watched with great interest. He was then at Treuvenberg Bay preparing his winter quarters with some of his companions, since the next day the last boat started from Spitzbergen leaving behind a few courageous men, who were to remain isolated from all the inhabited country for six or eight months.

In a letter dated September 13, 1899, M. Jäderin said to me: "I have the pleasure of informing you that our base measurements made this year have been a perfect success. Going and coming, we have measured a base of 10,024 meters in length. Up to the present, we have made but a provisional calculation, which gives a deviation of 19 millimeters only. For such calculation we have supposed that the wires underwent no expansion."

In his report upon the expedition published later on, M. Lacklund says: "The determination of the wires before and after the measurement of the bases does not permit of supposing that they varied during this operation; nor were any variations in length due to expansion."

The French expedition under the direction of Commander Bourgeois, which is operating at present under extremely difficult conditions in the upper regions of the Andes, upon the territory of the republic of Ecuador, is likewise making use of invar wire along with a bimetallic rule. The concordance of the measurements, which is of the order of 1/3,000,000, exceeds everything that could have been expected, and it is impossible to help thinking that, aside from the extreme care used by the officers of the mission in this double measurement, a fortunate accident has intervened to still further diminish errors.

At present, the majority of geodetic services are provided with invar wires, the use of which is becoming more and more general in measure as experiments accumulate and dissipate the prejudices with which a novelty is often received. The use of this wire is everywhere accompanied with a considerable increase in the accuracy of the measurements, as compared with that obtained by the quick processes that have been employed up to the present, or with a perceptible saving of time and money as compared with methods of high precision. A great base has already been measured in Germany, with a speed greater than three miles a day, despite the bad weather that continuously prevailed during the entire operation. Invar wires are now in service in Roumania, Servia, Cape Colony, Rhodesia, Madagascar, and Tonquin, and will be before long in Holland, the Dutch colonies, Mexico, the Argentine Republic, Egypt, and Switzerland. Such rapid development of their use is the best proof of the excellence of the results that they have given, or of the progress that is expected of them.

Under such circumstances, it may be asked why it is that several geodetic rules have been constructed in recent times. The reason is simple. The great geodetic services very naturally desire to still make base measurements by employing old processes, improved and simplified as much as possible, in order to obtain a direct proof of the accuracy assured by the new methods. Then, in a long and distant campaign, it may appear to be desirable, after the wires have been much used, to ascertain their value upon the very land of the base, in utilizing the rule solely for the measurement of a short distance, determined in a few hours, and upon which the wires are verified. Perhaps such control will be deemed superfluous in a near future. But, in the performance of fundamental operations, too many precautions cannot be taken.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the French of C. E. Guillaume in La Nature.

[Concluded from SUPPLEMENT No. 1536, page 24611.]

A BRIEF STUDY OF THE FERRO METALS AND THEIR ELECTRICAL MANUFACTURE.*

By AUGUSTE J. ROSSI.

PROPERTIES AND USES OF THE FERROS.

ALL the ferros are used in a general manner to impart to steel special qualities of hardness, toughness, ductility, strength, etc., and improving the ordinary steel treated. The combined use of two or more of these ferro metals may also, by counteracting in a finished product the influence of the other within certain limits, secure valuable properties for specific industrial applications. We will not enter into a detailed description of the properties and uses of these alloys, referring for further details to the special articles written on the subject, but will limit ourselves to indicating briefly their salient points.

Ferro-Chrome.—Ferro-chrome, free from carbon (less than 1 per cent), or, in some cases, containing 3 to 8 per cent carbon, is used more especially in the manufacture of shells and tempered products, tool steels and the like—in general, whenever properties of particular hardness are desired; though it secures them at some sacrifice in the toughness of the metal.

Ferro-Tungsten.—This alloy is very much looked for in the manufacture of tool steel, 9 to 10 per cent tungsten being found in the finished steel, and of late as much as 25 per cent tungsten has been or is to be introduced into steel, as we were told. The great weight of tungsten has suggested its use for bullets. Tungsten steel possesses a very peculiar property. When forged red hot and cooled slowly it presents an extraordinary degree of hardness, but if plunged red hot in cold water, contrary to what happens with ordinary carbon steel, this hardness gives way to softness.

Ferro-Molybdenum.—Ferro-molybdenum, used in steel in such quantities as to incorporate in the metal 2 to 3 per cent of molybdenum, imparts to it the peculiar property of "air tempering," or "self tempering." We have seen 13-inch shells, made of Carpenter steel, planed with such molybdenum steel tools, running dry, and which cut ribbons of steel hot enough to be blue without the tool losing its temper. Under certain conditions of heat treatment and quenching it imparts to steel other valuable properties, hardness being a characteristic.

Ferro-Vanadium.—This alloy appears to communicate to steel properties very much like those secured with nickel, and acts very much also like ferro-titanium. It is a new ferro, not very well known yet. It has been used chiefly experimentally. In the proportion of about 0.50 per cent in the steel, vanadium is said to increase the elastic limit wonderfully. It is very infusible, and in this respect stands next to ferro-titanium. One of the great drawbacks of its use is the scarcity of its ore, which must be highly concentrated, as it occurs sparingly in some rocks and commands a high price. The very lowest price we have heard quoted for vanadic concentrates is 50 cents per pound.

Ferro-Silicon.—Ferro-silicon, electrically smelted and containing some 25 to 30 per cent silicon and up to 50 per cent, has been much used of late in the manufacture of steel castings. It secures soundness and freedom from blow holes in the castings. It resists atmospheric influences remarkably well whenever the percentage of silicon reaches 25 per cent or thereabout, the effect increasing with the percentage of silicon.

Ferro-Manganese.—Manganese steel containing 6 per cent manganese or thereabout loses its magnetic properties, and at 13 to 14 per cent manganese it is practically non-magnetic. It possesses a great resistance to fracture by concussion. The maximum of strength appears to be secured in steel containing some 14 per cent manganese. Such steels have been used for forgings, car wheels and crushing and grinding machinery. It is toughened by water quenching, but does not temper in the sense in which the word is generally used.

Ferro-Nickel, Nickel.—Its uses for armor plates, boiler plates and structural steel have stood the tests of a prolonged practice. Some 3 to 5 per cent nickel is generally admitted to be necessary in the finished steel to secure the proper results. As much as 20 to 22 per cent nickel has been proposed for boiler plates. A 30 per cent nickel steel is well adapted for service in salt water on account of its resistance to corrosive action. Its recognized action upon steel is to secure a high elastic limit and strength combined with toughness.

As to ferro-titanium it was only mentioned as a laboratory curiosity some four years ago. Its influence on the properties of cast iron and steel has become better known and appreciated within the last two years. As it is a subject on the development of which we have worked for several years, we will give below the results of the numerous tests made by us or others with ferro-titanium of different percentages of titanium, free or with carbon, manufactured by us on an industrial scale by the ton in the case of some of them.

Ferro-Titanium.—It can be manufactured by either of the two methods described, and, according to which is followed, it contains carbon less than 1 per cent or up to 8 per cent. We have found, and in that we are corroborated by European practice with the ferro-titanium obtained there by Dr. Goldschmidt's aluminium powder method, that as the percentage of titanium increases the alloy becomes less and less fusible. In fact, 10 per cent ferro-titanium does not melt at the melting point of cast iron or steel, though it dissolves in the molten metallic mass, particularly if it is used in a smaller state of division. This is true also to quite an extent for most of the other ferros when high in the metal alloyed with iron. The specific gravity decreases with the percentage of titanium, this metal having a specific gravity of only 4.87 (Moissan). We have found 5.60 as the specific gravity of a ferro-titanium containing 35 per cent titanium with 7 to 8 per cent carbon. On account of this infusibility we are of the opinion that, for cast iron treatment, 10 per cent ferro-titanium should be preferable, and for steel not over 20 to 25 per cent ferro-titanium.

An article published in Stahl und Eisen contains the following, in substance: "The alloys carrying 40 per cent titanium or more have presented such difficulties for metallic applications, owing to their high melting point, that alloys carrying 20 to 25 per cent titanium are preferred. Even these should be heated previous to their addition to steel. Very small quantities of titanium, as little even as 0.10 of 1 per cent give, as is well known, a great density and close grained texture to the steel metal, and a remarkable tenacity. . . ." In fact, all our own experiments and those of others have shown that the addition of 1 to 2 per cent of a 10 per cent ferro-titanium, or even less in certain cases, will secure the desired effect.

The action of titanium, apart from any specific influence it may have on the finished steel if present in more important quantities, appears to be at least one of purification by removing the gases, such as oxygen, and specially nitrogen, contained in the steel. Titanium, as is well known, burns in nitrogen with incandescence at a temperature of about 1,500 deg. F. (800 deg. C.). In this manner blow holes may be avoided in the cast metal or ingots very much as ferro-manganese eliminates the oxygen in the Bessemer or open hearth process.

In the article of Stahl und Eisen, quoted above in substance, we find indeed this same statement, as follows: "The presence of cyanonitride of titanium in minute red crystals was observed with the microscope in steel treated with titanium." For this reason we have suggested the use of ferro-titanium containing carbon in the converter, both as a recarbonizer and a purifier. In our experiments with steel, made in the crucible, the addition of an alloy free from carbon seems to have imparted to high carbon steel, containing 0.83 to 1.22 per cent carbon, a remarkable elastic limit, as high as 76,000 pounds per square inch in some tests, and increased the reduction of area and elongation, but particularly the former, to figures met only with much softer steel. In an 0.83 per cent carbon steel with 0.09 per cent titanium a reduction of area of 21.90 per cent was recorded, and with a 1.22 per cent carbon steel with 0.12 per cent of titanium as much as 30.90 per cent reduction of area was observed. The fracture of the steel presented in both cases a fine silky appearance.

Our own experiments with cast iron have been very numerous, and some have been carried on in the cupola, on a large scale, by outside parties, for car wheels. The ferro used in all these cast iron tests was a 10 per cent ferro-titanium containing about 7 to 8 per cent carbon, and the tests were made in the crucible, the ladle or the cupola. We may state, generally, that foundry iron thus treated was found to be free from blow holes, the metal was dense, close grained, taking a fine polish, soft to the file, and particularly well adapted, we are told, for steam cylinders, iron pipes, return bends, fittings and kindred uses. Both the transverse and tensile strengths showed considerable increase, varying from 20 per cent or somewhat below to 30 per cent, according to the quality of the original pig metal treated. In our experiments, when operating in crucibles, we generally treated 100 pounds of metal, placing together side by side in the same coke fire one crucible charged with the pig iron without any addition of any kind, and the other with the same pig iron to which was added the desired percentage or amount of ferro-titanium alloy to be experimented with. Both vessels were then submitted to the same heat, under the same conditions, for the same period of time, and the metal was cast in both cases in bars 1 x 1 x 13 inches long, square, and in round bars 1¼ x 18 inches long.

When operating in a ladle we placed at the bottom of a receiving ladle the proper amount of alloy in coarse grains or fragments and poured the metal into the ladle from the cupola, stirred with a rod and cast in bars. A second ladle of the same capacity was then filled from the cupola (without any addition of alloy), and the metal cast also in bars.

When operating in the cupola, the alloy, in small fragments or pieces about the size of a nut, was charged proportionally to and with the different layers of pig iron, the cupola started and the metal cast in ingots and bars. The cupola was then dropped, charged with the same pig iron as before without any addition of alloy, and the melted metal cast in ingots and bars. By breaking the ingots the difference in the fracture, the closeness of the grain and other physical characters of the two metals could be observed.

In the results that are given below our results are tabulated per square inch after proper correction for measurements of the bars made before testing them. When tests were made by outsiders we give the results as they were communicated to us. The amount of alloy added was most generally 1 to 2 per cent, but sometimes as much as 3 and 4 per cent. Above the first two percentages the increase of strength is not apparently in proportion to the amount of ferro added. This is easily understood when it is considered that unless we operate in a crucible we are limited by the time, as it is not safe to delay the casting too long when operating in a ladle, and then a part of the ferro added may remain untouched, about 2 per cent only being really utilized and incorporated. The same may be said, to a certain extent, when experimenting in small cupolas, but with larger cupolas the improvement increases decidedly with the quantity of alloy added. However, if it be conceded that, with 1 to 2 per cent of alloy added, such an increase of strength as recorded is secured, the question of extra cost with greater additions may well be considered, as we cannot expect to increase the strength of cast iron beyond certain limits, and a maximum strength must necessarily be reached whatever may be the quantity of ferro-titanium added.

For ordinary use in foundries we have manufactured a special alloy (with carbon) containing 3.50 to 5 per cent of titanium, which, like the higher alloys, can only be obtained in the electric furnace, and we have found that such alloy melts at the temperature of cast iron and steel. We have cast it in regular pigs, and it can be used with other irons in mixture in the cupola. Some 3 to 4 per cent of such alloy will secure the same results as 1 to 2 per cent of the 10 per cent ferro-titanium, and it does not require any preparation or manipulation. It is, to all purposes, pig iron like any other but very high in titanium.

CAST IRON TESTS.

The alloy used in these tests was a ferro-titanium containing 10 per cent titanium and 7 to 8 per cent carbon. The square bars were cast 1 x 1 x 13 inches long, so as to leave 12 inches between bearings when tested. The round bars for tensile strength were 1¼ inches diameter by 18 inches long. Bars were merely cleaned on the surface but not machined.

The results of these tests go to show that the addi-

* From the Iron Age.

tion of from 1 to 4 per cent—on an average 2 per cent or less of a 10 per cent ferro-titanium—to cast iron secures a very material increase in the strength of the metal. The amount of alloy added, and the results obtained varied chiefly with the state of division of the alloy used, which was sometimes coarsely granulated, at other times in small fragments, frequently too large for a good incorporation of the greater amounts added, specially when operating in ladles. We have been able to alloy with the cast iron as much as 10 per cent of the ferro, operating in a special manner in crucibles. The pig metal obtained contained 1 per cent of titanium (1.04). Cast in slabs about 1 inch thick, it could not be broken with a 20-pound sledge, the blows making indentures in the metal without breaking it, and it was only after a number of such blows repeated have found by experience since. The incorporation was not as complete as it would have been with alloys containing only 20 to 25 per cent titanium and even less, and the analyses of the steel showed that only a part of the ferro added proved effective.

EXPERIMENTS WITH CRUCIBLE STEEL.

The steel was cast in 100-pound ingots at Atha & Illingworth Steel Works of East Newark, N. J., and test bars of the United States regulation size—viz., 2 inches long between threads and 0.20 square inch area—were made from them. The ingots were drawn to regular size steel bars, from which were made cutting tools, drills, and chisels. The latter were used for chipping hard steel ingots, and proved, it was said to us, particularly well adapted for this use, as the head "did not mushroom." The charges in the crucible were

Tests in Ladle.

By whom tests were made.	Pig metal tested.	Transverse strength in pounds per square inch. Tensile strength in pounds per square inch. Breaking load.	Increase. Per cent.	Breaking load.	Increase. Per cent.	Deflection at center of bars. Inches.	Inc. Per cent.	Remarks.
Car Wheel Works (in our presence).	Original.	21,000	..	2,200	..	..	..	
	+ 2 % alloy.	27,500	30	2,710	23	..	..	
	Wheel mixture.	.....	..	2,900	..	..	..	
	+ alloy.	.....	..	3,670	27	..	..	
Abendroth & Root, Greenpoint, N. Y. (in our presence).	Original.	20,500	..	2,030	..	..	..	Bars cast horizontally. Alloy used in lumps in a small ladle, 200 to 300 pounds capacity.
	+ 1 %	22,200	+ 8½	2,100	..	..	..	
	+ 2 %	24,600	20	2,200	10	..	..	
	+ 3 to 4 %	25,900	26	2,550	25	..	..	
	Original.	16,600	..	1,693	..	..	..	Bars cast vertically. (Same as above.)
	+ 2 to 3 %	20,600	24	2,350	39	..	..	
A. J. Rossi, Buffalo.	Original.	.....	..	3,084	..	11	..	Best foundry iron.
	+ 1 % alloy.	.....	..	3,550	15	13	18	
	+ 2 % alloy.	.....	..	3,775	22½	14	27	

N. B.—Tests made by us or in our presence refer to a corrected area of 1 square inch.

Experiments in Crucibles.

By whom tests were made.	Pig metal tested.	Transverse strength in pounds per square inch. Tensile strength in pounds per square inch. Breaking load.	Increase. Per cent.	Breaking load.	Increase. Per cent.	Deflection at center of bars. Inches.	Inc. Per cent.	Remarks.
A. J. Rossi, Jersey City Foundry.	Original.	13,560	..	1,820	..	0.08	..	Very weak pig iron. Phosphorus, 0.89 per cent.
	+ 2 %	21,800	62	2,300	26	0.11	27	
	+ 3 %	23,600	74	2,400	32	0.13½	50	
Wm. Cramp & Son shipyard. Official report. Letter from Wm. Cramp.	Original.	20,372	..	2,046	..	0.11	..	Copy from official test.
	+ alloy.	26,409	29.60	2,473	21	0.14	27	
	.....	.....	29.50	..	..	..	..	Second test.
Niagara Falls Foundry. A. J. Rossi.	Original.	21,000	..	2,150	..	0.09	..	
	+ 2 % alloy.	27,500	31	2,750	28½	0.12	33	
Car Wheel Works, Pennsylvania (in presence of A. J. Rossi.	Original.	22,900	..	2,275	..	..	..	Alloy in coarse grain.
	+ 2 % alloy.	30,000	31	2,850	25	..	..	
	Original.	18,000	..	1,900	..	..	..	Alloy in small pieces.
	+ 1 % alloy.	22.300	24	2,300	21	..	..	
	Wheel mixture	23,900	..	2,400	..	..	..	Granulated alloy.
	+ alloy 1 %	30,500	27½	2,900	21	..	..	
A. J. Rossi. Tests at Dr. C. F. McKenna. Reported by him.	Original.	25,400	..	2,500	..	0.10	..	Paterson, N. J. Pig iron for pipes.
	+ 2 % alloy.	30,500	20	3,100	24	0.125	25	

Experiments in Cupola.

By whom tests were made.	Pig iron tested.	Transverse strength in pounds per square inch. Tensile strength in pounds per square inch. Breaking load.	Increase. Per cent.	Breaking load.	Increase. Per cent.	Deflection at center of bars. Inches.	Inc. Per cent.	Remarks.
Keystone Car Wheel Company, Pittsburgh. Letter from president.	Car wheel mixture.	.....	..	3,000 to 3,200	17 to	..	..	
	+ alloy.	.....	..	3,500 to 3,740	25	..	..	
Car Wheel Works (in presence of A. J. Rossi).	Foundry pig	23,000	..	2,400	..	..	..	Alloy used in grains.
	+ 1 %	28,900	26	2,900	21	..	..	
	Wheel mixture	23,900	..	2,400	..	..	..	Coarse grain alloy.
	+ 1 to 2 %	30,000	25½	2,950	22½	..	..	
A. J. Rossi, Girard College, Philadelphia.	Best coke iron	24,960	..	2,600	..	0.13	..	
	+ 1 to 2 % (lumps)	28,860	16	2,880	11	0.15	15½	Warwick pig iron. Coke.
	Best charcoal Scotch pig.	28,000	..	2,800	..	0.14	..	
	+ 2 % alloy (lumps)	32,900	18	3,200	14	0.15½	11	Muirkirk Scotch pig. Charcoal.

on the same spot that small chips of the plate (almost forged) could be detached.

When we have quoted experiments made by outside parties in the preceding tables we have recorded the results as they were communicated to us, as will appear from the following:

In a letter of Wm. Cramp, of May, 1901, we find: "Our tests with ferro-titanium in connection with iron castings made from a crucible have shown an increase in tensile strength over our ordinary castings of about 29½ per cent, and over cast iron with an addition of nickel of 4 per cent."

In a letter of August 20, 1902, C. V. Slocum, president Keystone Car Wheel Company, Pittsburg, writes:

"For the first half of the heat and during the time no titanium was used a strength of about 3,000 pounds was obtained from test bars, the highest strength observed being 3,270 pounds. In the last half of the heat, during which a small part of the titanium was in the charge, the strength ran up at once to 3,500 pounds, and one bar, which would evidently have run considerably over, was removed from the machine without breaking. We had bars breaking at 3,740 pounds on different days, each of which contained titanium."

In a paper read by C. V. Slocum before the Railway Club of Pittsburg, on November 28, 1902, he says:

"Titanium is known to be of great value in car wheels, having the effect of hardening the tread and strengthening all parts of the wheel, including the plates. . . ." And further:

"Our own experiments with the metal demonstrate that titanium in iron gives greater density to the metal, surprisingly increases transverse strength, and gives harder chill and wearing qualities to the wheel."

As far as steel is concerned, the results of German practice, as has been quoted above from Stahl und Eisen, corroborate in the main particulars those we have made ourselves with crucible steel on a limited scale, and the most interesting of which we give below. We made in all ten ingots of steel treated with titanium, and we used as addition ferro-titanium practically free from carbon (0.28 C) containing 35.41 per cent of titanium, and also a ferro-titanium with 35 per cent titanium containing 7 to 8 per cent carbon. This percentage of titanium was too high, as we and others mostly scrap iron and low carbon steel, with no additions of manganese or tungsten, nor of slag materials, the carbon in the alloy added being depended upon to furnish the percentage desired in the finished product when carbon alloys were used.

The silicon in the steel was about 0.25 per cent, varying from 0.21 to 0.28 per cent, the phosphorus and sulphur at or below the Bessemer limit, the alloy being quite free from these elements.

Tests.	Tensile strength per sq. inch.	Elastic limit, Pounds.	Elongation in 2 inches. Per cent.	Reduction of area Per cent.	Carbon in steel, Per cent.	Titanium in steel, Per cent.
No. 1.	64,500	33,750	27.30	44 60	0 38	0 045
No. 2.	122,500	66,500	11.10	16.60	0.83	0,06
No. 3.	127,500	70,000	8.40	21.90	0.84	0,065
No. 4.	141,000 to 146,700	76,500	8 40	14.60	0.82	0,078
No. 5.	....	59,250 to 62,000	10 00	30.90	1.227	0.11 0.119

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Stahl und Eisen, June 1, 1901, Düsseldorf meeting, vol xxi, No. 11; and many other articles in the Iron Age and other technical journals.

Formaldehyde Mouth Wash.—Take 50 parts of 40 per cent formaldehyde solution, 50 parts tincture of myrrh, 3 parts of oil of peppermint, 2 parts of aniseed oil, 1 part of Chinese cassia bark oil, 15 parts of Ceylon cinnamon oil, 2 parts of cochineal, and 1,000 parts of alcohol. These, well mixed and blended as they will become in a short time after being put together, will furnish a most delicious mouth wash.—Drog. Rundschau.

ENGINEERING NOTES.

Economy of Concrete as Building Material.—As the use of concrete for building purposes is becoming more general, comparative figures of the cost are of interest. According to a German periodical, Herr Biedermann, as the result of an elaborate calculation, computes the cost of a cubic meter of brick masonry at 28 marks, and of ashlar at 23 marks at least, whereas the cost of concrete falls below 15 marks.

Mr. Druitt Halpin's system of heat storage has been applied to a locomotive boiler of the Great Northern Railway of England. A cylindrical storage tank is placed on top of the boiler, to which it is connected by means of a pipe. The feed water, heated to the same temperature as that of the boiler, is passed through this cylinder, the heating being done by steam taken from the boiler when the engine is standing or the safety valves are blowing. In this way a large supply of heat is available to help the boiler when running. In stationary practice a test by Prof. Unwin has shown a coal saving of 19 per cent with this system.—American Engineer and Railroad Journal.

Thermodynamics and Engineering Problems.—Prof. Bouloin, of the University of Ghent, has just issued a new edition of his work, Théorie des Machines Thermiques, adapting it to the consideration of new problems, which are often too much confined to mere mechanical improvements. Thermodynamics does not afford the solution of problems relating to the employment of heat except approximately, as for hypothesis assumed for facilitating calculations, or for supplementing the lack of data of experience. Although it is impossible to find *a priori* the quantitative results requisite for establishing a caloric machine, the study is not the less indispensable for the engineer. So, six chapters have been devoted to general thermodynamics and the flow of fluids, and to hot air, gas detonating, steam and freezing machines. Turbines, explosion motors, superheated steam appliances, and recent novelties in general are reviewed.

The Great Northern Railroad is the latest English railroad to adopt the "Atlantic" type of locomotive. This engine is a four-cylinder compound, and has been constructed from the designs of the railroad engineer, Mr. H. A. Ivatt. It has been designed for hauling the heaviest of the East Coast Scotch expresses between York and London, and for the more important West Riding trains between London and Leeds. The four cylinders are placed abreast, and drive on to separate axles. The outside high-pressure cylinders are 13 inches by 26 inches; the inside low-pressure cylinders, 16 inches by 26 inches. The starting valve is of the engineer's special design, and provides for the engine working either simple or compound. The four-coupled wheels are 6 feet 6 inches in diameter. The total heating surface of the boiler is 2,500 square feet, the tubes contributing 2,339 square feet, and the firebox the remainder. The increased size of the boiler has necessitated its centre line being extended 8 feet 8½ inches above rail level. The engine, in working order, weighs 65 tons, and the tender 40 tons, making an aggregate weight of 105 tons. The tender is six-wheeled, with a capacity for 3,700 gallons of water and 5 tons of coal.

Draft Indicators.—Instruments for indicating the draft are capable of important service in the management of boilers. The apparatus is simple. The index is solidly connected with a membrane, which is subjected on one side to the pressure prevailing in the fire-box, and on the other to atmospheric pressure, or to that in the flue. Different indicators are described by Herr Dosch, in Dingler's Polytechnisches Journal, of which the Dürr apparatus is typical. It consists of a reservoir half filled with oil, in which floats a closed vessel, capable of oscillating around the beam of a balance and poised by a counterweight on the opposite arm of the beam. Tubes put the interior of the reservoir in communication with the air of the fire-box, and the interior of the inner vessel with the air of the flue. The oscillations are registered by a style on a paper cylinder. The fireman, by observing the instrument, is able to bring the draft to its most useful point, and also able to ascertain the condition of the fire. Erroneous conclusions may sometimes be drawn, but the operative who makes himself familiar with the apparatus and gives it suitable attention, can derive decided advantage.

There are now automatic apparatus for the boiler room which continually indicate condition of combustion according to percentage of CO_2. The econometer and dasymeter are purely mechanical devices; the gas composimeter and the ados apparatus are chemical instruments; the latter two make permanent records; the dasymeter is made with and without recorder, and the author has devised and in one case applied a recording attachment to the econometer, which makes a record on a 24-hour circular chart similar to, and as convenient as those from the Bristol recording instruments. No more instruments to indicate condition of combustion are required at present, but what is needed very badly, are some more engineers and proprietors who will appreciate and learn to use the instruments which are already available and to impress their value on the firemen by their own example. When it is considered that within about five years nearly every engineering college in this country has added to its equipment either an econometer or similar instrument, and that during this time their use has been largely discontinued, not through any fault of the instrument, but owing to neglect of the important economic feature which they represent, it is an indication that the fireman is not responsible for all of the trouble.

TRADE NOTES AND RECIPES.

Bleaching of Sponges.—The sponges are first washed in clean water and then immersed for twenty-four hours in a solution of water 9 liters and chlorhydric acid 1 liter. They are then washed again and immersed in the following solution: water, 10 liters; bromine, 40 grammes. In twenty-four hours the blackest and dirtiest sponges become perfectly white.—Polytechnisches Journal.

How to Protect Zinc Roofing from Rust.—Zinc sheets for roofing can easily be protected against rust by the following simple process. Clean the plates by immersing them in water to which 5 per cent of sulphuric acid has been added, then wash with pure water, allow to dry and coat with asphalt varnish. Asphalt varnish is prepared by dissolving 1 to 2 parts asphalt in 10 parts benzine; the solution should be poured evenly over the plates, and the latter placed in an upright position to dry.—Der Metallarbeiter.

Enameling of Metallic Surfaces.—Herr Lonholdt, of Berlin, proposes an efficacious means for protecting metallic surfaces when in contact with fire. The process consists in applying a layer of a mixture of 50 grammes of fossil silicate with a small quantity of tin cinder or boracic acid, 200 grammes of graphite and 20 grammes of red ocher. The mixture is stirred with 0.05 of pure water, with the addition of 0.75 soluble glass of soda base, until a homogeneous solution is obtained. This is spread uniformly on the metallic surfaces, which are afterward exposed to the fire. The coating then becomes alloyed with the metal and is converted into enamel.—Kosmos.

Bronzing of Cast Iron.—The Maschinenbauer contains the following description of a process whereby cast iron may be made to assume the appearance of bronze without the necessity of coating it with metal or alloy. The surface, previously cleaned and polished, is evenly painted with a vegetable oil, e. g., olive oil, and then well heated, care being taken, however, that the temperature does not rise to a point at which the oil will burn. The cast iron absorbs oxygen at the moment when the decomposition of the oil begins, and a brown layer of oxide is formed which adheres firmly to the surface and which may be vigorously polished, giving a bronze-like appearance to the surface of the iron.

To Give a Silver Color to Iron.—A brilliant silver color may be imparted to iron from which all grease has been previously removed by treating it with the following solution: 40 grammes chloride of antimony, 10 grammes powdered arsenious acid, and 80 grains levigated hematite are mixed with 1 liter of 90 per cent alcohol and gently heated for half an hour in a water bath. A partial solution takes place, and a small cotton pad is then dipped in the liquid and applied with a gentle pressure to the iron. A thin film consisting of arsenic and antimony is precipitated, as described by Dr. Langbein in his "Handbuch der galv. Metallniederschläge." The brilliancy of the effect depends upon the care with which the iron has previously been polished.

Preservation of Belting.—In a well-covered iron vessel heat at a temperature of 50 deg. C. 1 kilogramme of caoutchouc, cut in small pieces, with 1 kilogramme of rectified turpentine. When the caoutchouc is dissolved add 800 grammes of colophony, stir until this is dissolved, and add to the mixture 100 grammes of yellow wax. Into another vessel of suitable size pour 3 kilogrammes of fish oil, add 1 kilogramme of tallow, and heat the mixture until the tallow is melted; then pour on the contents of the first vessel, constantly stirring, an operation to be continued until the matter is cooled and congealed. This grease is to be rubbed on the inside of the belts from time to time, while they are in use. It gives great stability, and they run easily over the pulleys and do not slip. It may also serve for improving old belts. For this purpose the grease should be rubbed on both sides in a warm place. A first layer is allowed to soak in, and another applied. Belts thus treated may still serve for a long time.—Kosmos.

Some Important Varieties of White Brass.—White brass is composed of alloys of copper and zinc containing from 50 to 80 per cent of zinc and having a color between silver-white and bright yellow. All the alloys belonging to this class are exceedingly hard but very brittle, and are therefore only adapted for the manufacture of castings. These alloys are frequently used in making coat buttons, candlesticks, teapots, and other articles not exposed to much rough handling; they are not very suitable for other purposes, as they are so brittle that they can be broken by a vigorous blow. These alloys are composed as follows: Forbes alloy: 46.5 parts by weight of copper, 35.5 of zinc; silver white and very brittle; used almost exclusively for buttons. Birmingham button metal: 43 parts by weight of copper, 57 of zinc. Buttons made of this alloy are known in the trade by the name of "platina buttons." German button metal: 20 parts by weight of copper, 80 of zinc. Buttons made of this alloy are also, but erroneously, called "Tombac buttons." Bath metal: 55 parts by weight of copper, 45 of zinc. Owing to its greater content of copper this alloy has a pronounced yellow tint, and is less brittle than the compounds already mentioned. It is frequently used in the manufacture of teapots, dishes, candlesticks, etc. Articles made of this alloy take a good polish.—Der Metallarbeiter.

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